RHODORA

JOURNAL OF THE
NEW ENGLAND BOTANICAL CLUB

Vol. 96 April 1994 No. 886

RHODORA, Vol. 96, No. 886, pp. 121–169, 1994

THE ENVIRONMENT AND VASCULAR FLORA OF NORTHEASTERN IOWA FEN COMMUNITIES

JEFFREY C. NEKOLA

ABSTRACT

While fen communities have been long known from northwestern Iowa, only recently have they been found to occur in northeastern Iowa, south of the limit of Wisconsinan glaciation. Since 1984, over 2333 potential fen sites were surveyed in this region, and 160 were found extant. Extant fen sites can be divided into one of five classes dependent upon surficial geology: pre-Illinoian till, bedrock, eolian sand, fluvial sand, and oxbows. Five of eight soil chemistry variables differed significantly across these geologic classes, including organic matter, pH, available phosphorus, calcium, and magnesium. Soil pH, organic matter, and available magnesium were found to have fairly well-defined spatial gradients across northeastern Iowa fen sites. Four principal axes of climatic variation were also described from northeastern Iowa, and include temperature, precipitation, growing season, and summer precipitation. A total of 320 vascular plant taxa were located or have been reported from this community, with seven being only known from historical records. Fully 44% of the flora are considered rare in the region or state. Of these, 30% are rare in northeastern Iowa, 20% are rare in the state, 12% are listed for state legal protection, 11% are newly known from the northeastern Iowa flora, and 4% are newly known from the Iowa flora. Even though northeastern Iowa fens currently cover only .01% of the northeastern Iowa land surface, they contribute significantly to state and regional biodiversity by harboring approximately 28% of the regional and 18% of the total state flora.

Key Words: fens, Iowa flora, rare species, biodiversity

INTRODUCTION

Fens are peatland areas whose source water has been enriched in nutrients by passage through the ground (Sjörs, 1952; Moore and Bellamy, 1974). While covering a large extent of the boreal North American landscape (Horton et al., 1979; Glaser, 1987), along the glacial margin in North America fens are generally

Table 1. States in the eastern U.S. where fens have been reported.

State	Selected References
Connecticut	LeFor, 1986
Illinois	Sheviak, 1974
	Swink and Wilhelm, 1979
	Moran, 1981
Indiana	Friesner and Potzger, 1946
	Shuey, 1985
	Wilcox et al., 1986
Iowa	Anderson, 1943
	Nekola and Lammers, 1989
Kansas	Horr and McGregor, 1948
	Grüger, 1973
Massachusetts	Weatherby and Crow, 1992
Michigan	Cain and Slater, 1948
	Schwintzer, 1978
	Kron, 1989
Minnesota	Glaser, 1987
	Coffin and Pfannmuller, 1988
Missouri	Steyermark, 1938
	Orzell, 1983
	Nelson, 1985
Nebraska	Kaul et al., 1988
New Jersey	Breden and Smith, 1988
New York	Stewart and Merrell, 1937
	McVaugh, 1958
North Carolina	Schafale and Weakley, 1990
North Dakota	Seiler and Barker, 1985
	Malterer and Bluemle, 1988
Ohio	Gordon, 1933
	Andreas, 1985
	Stewart, 1987
Pennsylvania	Conard, 1952
	Breden and Smith, 1988
South Dakota	Over, 1932
	Ode, 1985
Virginia	Ogle, 1984, 1989
West Virginia	Hutton et al., 1968
	Bartgis and Lang, 1984
Wisconsin	Curtis, 1959
	Carpenter, 1990
	Reed, 1985

considered one of the rarest habitats in the landscape (Reed, 1985; Eggers and Reed, 1990). Fens or fen-like areas have been reported from a number of central and eastern states (Table 1), where they harbor a distinct flora including many rare species.

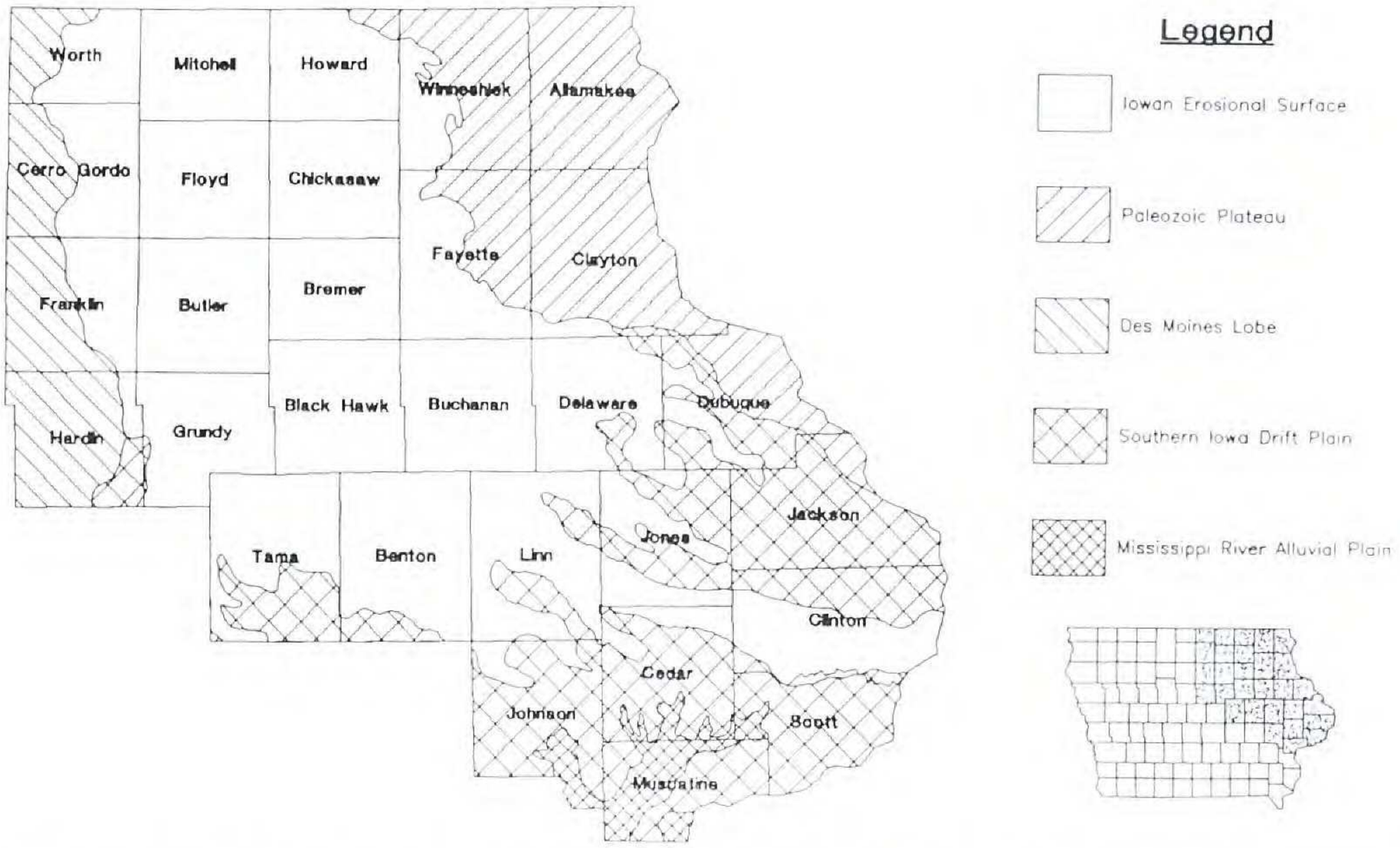

Figure 1. Landforms and counties included in the study region. Landform boundaries are based on Prior (1991).

Fens have long been the subject of research along the western side of the Wisconsinan terminal moraine in northwestern Iowa (Cratty, 1903; Wolden, 1926; Anderson, 1943; Hayden, 1943; Conard, 1952; Thorne, 1952; Holte and Thorne, 1962; Holte, 1966; van der Valk, 1975; Lammers and van der Valk, 1979; Moats, 1981). Until the mid-1980's biologists and ecologists thought that fens were restricted in Iowa to this region (e.g., Roosa and Eilers, 1978).

However, spring-fed, hillside peat deposits (termed 'mound springs') were also reported from northeastern Iowa in early geologic surveys (White, 1870; Calvin, 1897, 1902). These habitats remained biologically undescribed until 1984, when the flora of a northeastern Iowa site was studied (Nekola and Lammers, 1989). Like fens elsewhere in central and eastern North America, this site was found to harbor a large number of regionally rare species.

To better assess the regional fen environment across northeastern Iowa, and its contribution to local biodiversity, reconnaissance for all extant fen sites within the Iowan Erosional Surface, Paleozoic Plateau, and portions of the Southern Iowa Drift Plain and Mississippi River Alluvial Plain of Prior, 1991 (Figure 1) was conducted. Results from this survey will be used to address three main topics: (1) What was the original extent of fens in eastern Iowa, and how many remain extant? (2) What is the

environmental variation of the extant sites in terms of their underlying geology, soil chemistry, and regional climate? (3) What is the species diversity of these sites, and how do they contribute to state and regional biodiversity?

METHODS

A. Site Location

For purposes of this study, fens were defined as wetland areas with saturated but not inundated soils which are fed by permanent groundwater seepage. This definition differs slightly from those typically used by European researchers (e.g., Sjörs, 1952; Moore and Bellamy, 1974) in that sites which have saturated soils, but little or no peat accumulation are considered fens. The broader definition of 'fen' used in this study follows the precedent of many other U.S. fen researchers (e.g., Holte, 1966; Andreas, 1985; Weatherbee and Crow, 1992).

Potential fen sites in northeastern Iowa were located through use of county soil survey maps prepared by the USDA Soil Conservation Service (SCS). These modern soil survey maps have been completed for all counties within the study region. The location of potential sites was made possible as most occurrences of muck or peat soils (variously named 'Peat', 'Muck', 'Palms Muck', or 'Houghton Muck') are restricted to fen sites.

From 1984 to 1991 all occurrences of peat soil pedons occurring on SCS county soil maps in the 29-county study region were visited to determine the location of extant sites. Sites were considered extant if they possessed essentially undisturbed vegetation and/or rare species. A number of undrained sites that had been completely invaded by weedy plants such as *Phalaris arundinacea,* or had been grazed beyond recognition, were excluded from this list. The boundaries of all pedons of fen soil mapped by the Soil Conservation Service were digitized to provide a regional perspective on the distribution of presettlement and extant sites.

B. Soil Analysis

Four soil samples were collected from each extant fen in an attempt to capture the range of soil variation present. These samples were oven dried, and 50 g taken from each to make a single

composite sample for each site. Determination of percent organic matter, pH, NO_3-N, extractable P, exchangeable K, extractable SO_4-S, exchangeable Ca, and exchangeable Mg in these samples were conducted by Minnesota Valley Testing Laboratory of Nevada, Iowa, and followed the methodology of Dahnke (1988). These variables are referred to as percent organic matter, pH, P, K, S, Ca, and Mg, respectively, in the remainder of the paper. Water samples were not taken as standing water was not present at all sites, and as water samples could not be stored for later analysis. However, soil and water chemistry should covary as any dissolved or suspended particulates will remain in the soil after drying.

One-way ANOVA's were used to test the significance of differences for these soil variables across five classes of underlying surficial geology. An approximation of the spatial distribution of each variable across northeastern Iowa fen sites was estimated through the interpolation technique of block kriging (Burgess and Webster, 1980).

C. Climatic Analysis

Twenty-two climatic variables were calculated as 30-year means from 96 recording stations across Iowa. Principal components analysis was conducted on all variables to identify the most important axes of variation. These axes were related to the original variables through use of a vari-max rotation. To document the spatial distribution of each of these four main axes within the study region, the interpolation technique of block kriging was used to estimate the variation of each across the study region.

D. Floristic Analysis

Occurrence of all vascular plant species were noted for all extant northeastern Iowa fens. In addition, a survey was made of the northeastern Iowa botanical literature (Fitzpatrick, 1899; Barnes et al., 1900; Pammel, 1908; Guldner, 1960; Cooperrider, 1962; Hartley, 1966; Eilers, 1971) to identify all species that were historically known from these habitats but for which no extant populations could be located.

Five types of rarity within the flora were assessed. First, rarity

within northeastern Iowa is based on classifications provided from the two regional floras (Cooperrider, 1962; Eilers, 1971) whose boundaries fall entirely within the region of this current study. For a taxon to be considered rare within the region, it had to be considered either rare in both of these floras, or rare in one and absent from the other. Second, state-level rarity was assessed following Howe et al. (1984). Third, the listing of the taxa legally designated as 'Endangered', 'Threatened', and 'Special Concern' in Iowa was based on Roosa et al. (1989). Fourth, taxa new to the regional flora are based on Guldner (1960), Cooperrider (1962), and Eilers (1971). Lastly, the designation of taxa new to the state is based on those not found in published county and regional floras.

Voucher collections were made for all rare taxa occurrences by top-snatching relevant material so that populations would not be affected. Specimens were deposited at the R. V. Drexler Herbarium at Coe College, Cedar Rapids, Iowa. Where populations were large enough, duplicate specimens were also made and placed in the University of Iowa Herbarium, Iowa City, and the University of North Carolina Herbarium, Chapel Hill.

RESULTS AND DISCUSSION

A. Distribution of Presettlement and Extant Sites

In total, 2333 potential sites were identified from SCS soil maps in the 29 eastern Iowa counties surveyed (Figure 2a). Of these, only 160 remained extant by 1991 (Figure 2b). Site names, sizes, geologic class, and locations for these sites are given in Appendix I.

In presettlement, clustering of fen sites was present at a number of differing spatial scales. At a regional scale, sites clustered into two general groups: one paralleling the eastern margin of the Des Moines Lobe, and the other paralleling the eastern border of the Iowan Erosional Surface.

At smaller scales (approximately the size of counties), roughly parallel northwest-to-southeast trending bands of high site density

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Figure 2. Distribution of fen habitats in northeastern Iowa, based upon digitization of SCS county soil maps. a: Presettlement. b: 1991.

Figure 2a: Presettlement Fens

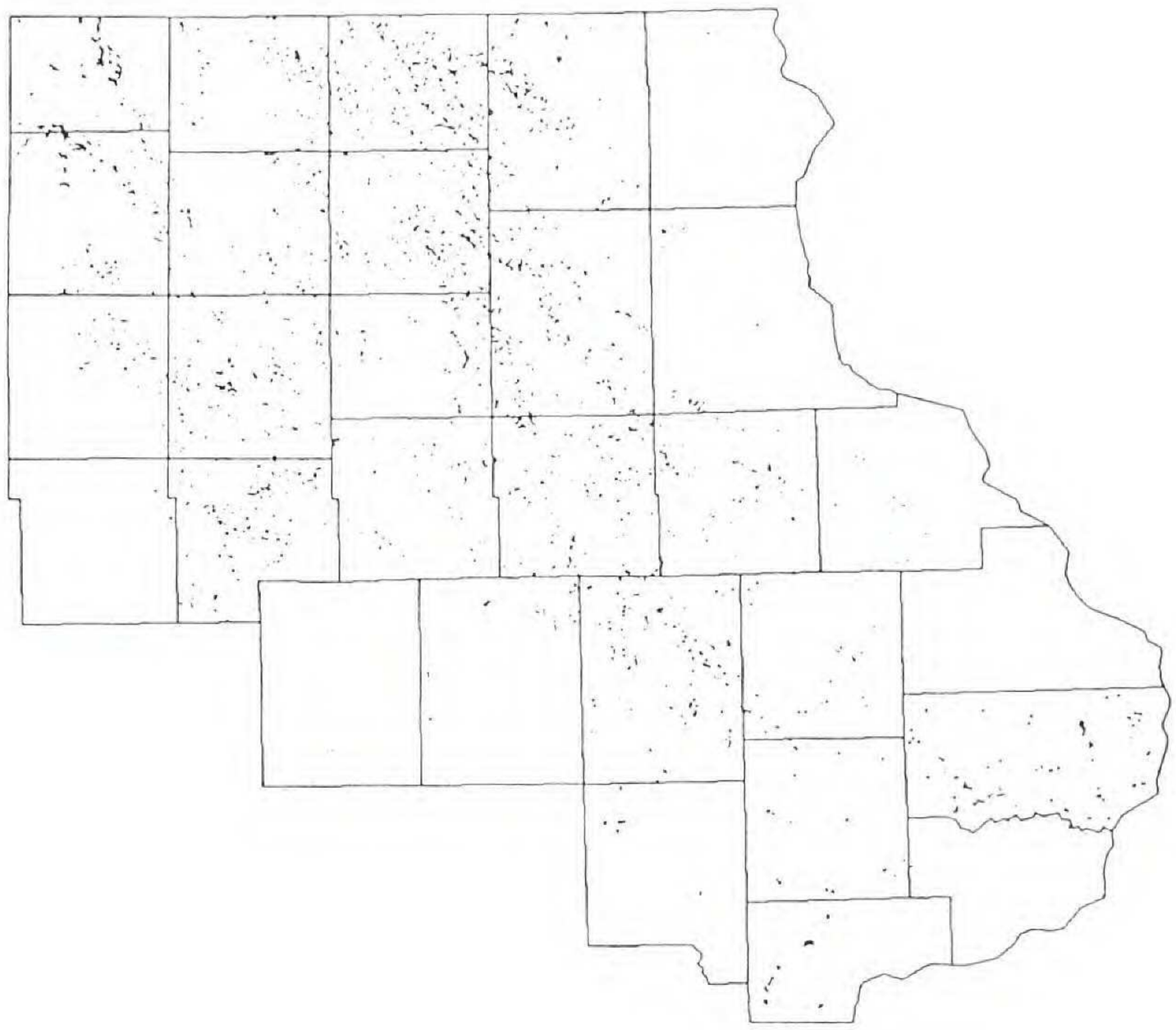
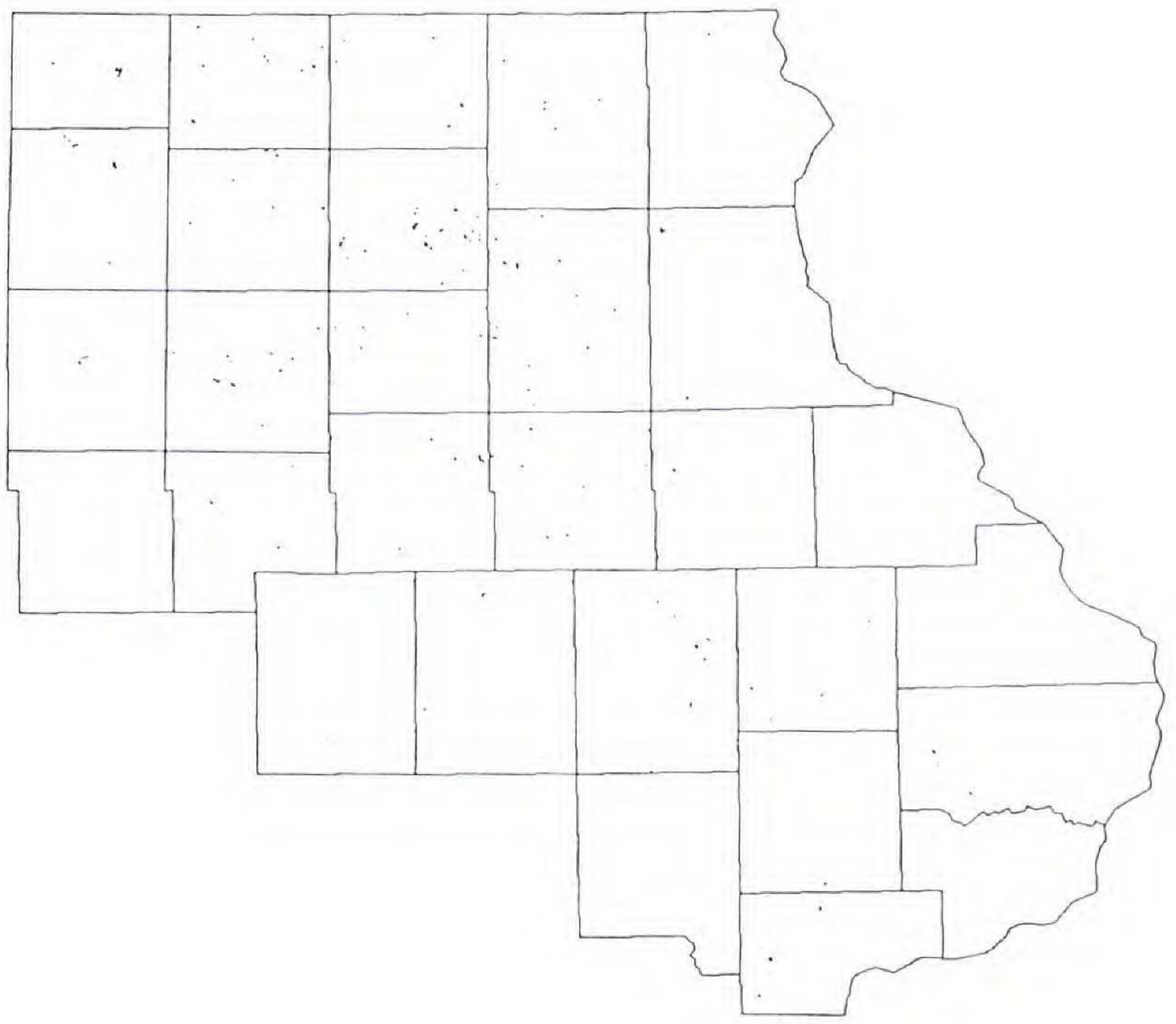


Figure 2b: Extant Fens - 1991



approximately 10–15 miles wide and 75 miles long occurred. In the western cluster, these bands seem to be closely related to outwash sands and gravels along the Winnebago and Shell Rock Rivers. In the east, longer and more diffuse bands are present which seem to cut across local drainage patterns and topography. One of the most marked of these concentrations begins in central Chickasaw County and terminates in northwestern Cedar County. It is possible that these bands of high site density correlate with locations of pre-Illinoian moraines where the concentration of upland gravel deposits are greater.

At even smaller spatial scales (roughly the size of a township) individual sites were often grouped into linear strings. The most intriguing of these are a parallel series of five such strings which extend over a 30 mile extent in Chickasaw, Howard, Fayette, and Winneshiek Counties. The underlying factors responsible for such pattern are not known.

While diverse spatial structure existed in presettlement site distribution, the loss of 93% of sites in the last 50–100 years has led to the destruction of almost all of this pattern. The distribution of extant sites now appears almost random, with even the large regional clusters being almost unidentifiable. This loss of spatial structure will probably lead to a decrease in the rate of immigration between sites, and alter the direction of species migration through the landscape.

SCS maps, which were used to generate these data, should not be considered infallible sources of information. Two caveats regarding their use in documentation of presettlement fen sites must be made. First, not all fen sites present in the presettlement landscape have been mapped. This form of error has led to the exclusion of some historic and extant sites from the published soil maps. For instance, a site near Tipton described by White (1870) is not mapped in the Cedar County soil survey. Also, eleven percent of the extant sites listed in Appendix I were not mapped as possessing fen soil pedons, and were located by visual inspection during field reconnaissance or from local contacts.

The second form of error in soil survey mapping of potential fen sites occurs when marsh habitats with peat accumulations are mapped as possessing soils characteristic of fen sites. Although such wetlands may have muck or peat soils, they do not provide proper habitat for fen species, and do not represent potential fen habitats. The mapping of all muck soil pedons in such cases will

overestimate the number of presettlement fen sites. This error is most prevalent in the western counties bordering the Des Moines Lobe, where numerous pothole marshes with peat accumulations were present prior to draining. Some of the mapped areas of peat or muck soil in Clinton County may also represent former marsh habitats. This form of error was minimized by only digitizing sloping, hillside peat pedons on the Des Moines Lobe, thereby removing potential marsh habitats from analysis. As it was not possible to make any *a priori* rules for exclusion of potential Clinton County marsh sites, all peat pedons in that county were mapped. However, field observations suggest that less than 10% of potential Clinton County sites represent former marsh sites, indicating a relatively low rate of this form of error.

Although county soil maps represent an imperfect data source, they are the best and only estimate available of the presettlement extent of fens in northeastern Iowa. As both of these error rates are relatively low (approximately 10%), the analysis presented above should thus reflect the trends in site distribution once present in presettlement landscape.

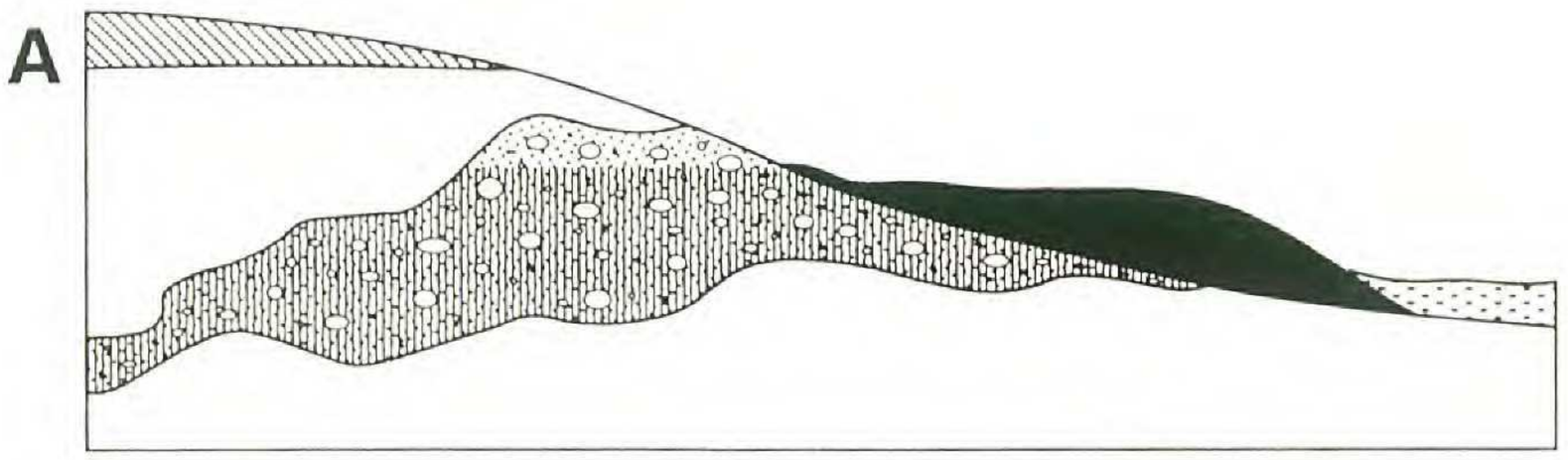
B. Environmental Variation Across Northeastern Iowa Fen Sites

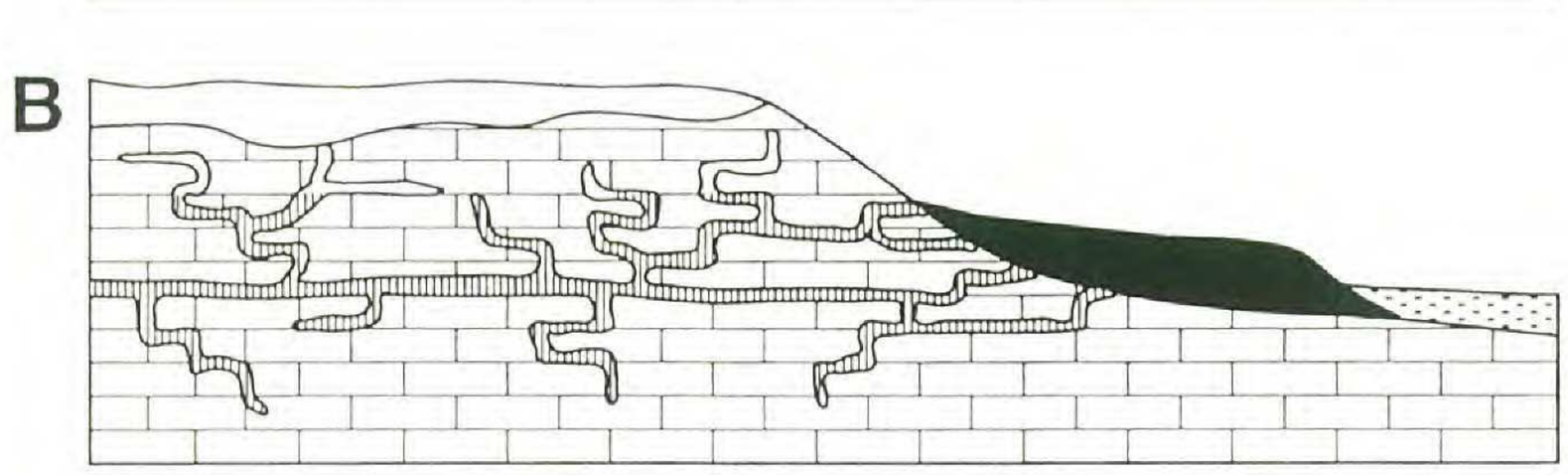
Geologic Classification

The majority of the region included in this study was unglaciated during the Wisconsinan and subjected to intense periglacial erosion which removed existing tills and exposed water-bearing till or bedrock sequences, created stepped landscape surfaces, and prevented deep accumulations of loess (Hallberg et al., 1978; Prior, 1991). The sediment liberated through periglacial erosion was deposited as eolian and fluvial sands along major river corridors (Prior, 1991).

Depth of loess accumulation appears to negatively covary with abundance of fen sites. On the southern margin of the study region in Tama, Benton, Cedar, and southern Linn Counties where periglacial erosion was less intense and loess deposits accumulated (Anderson, 1983), fens are much less frequent than in the till-mantled or bedrock-controlled landscapes to the north which experienced higher erosion rates.

The 160 extant fens in northeastern Iowa were classified into


A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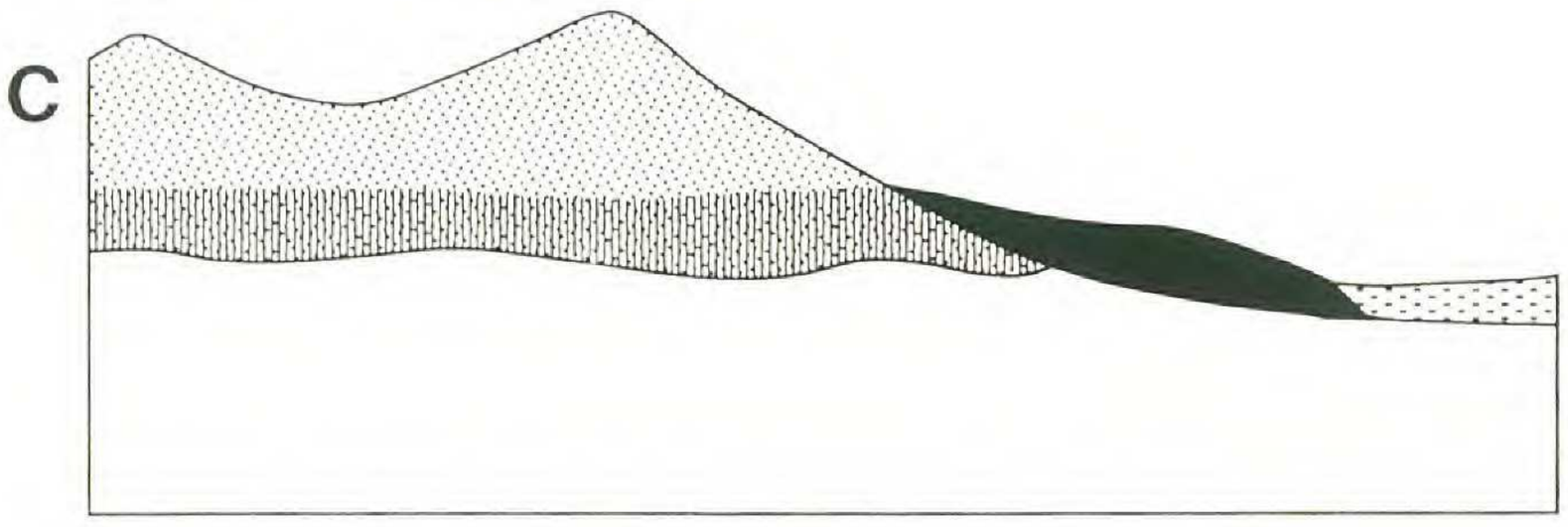
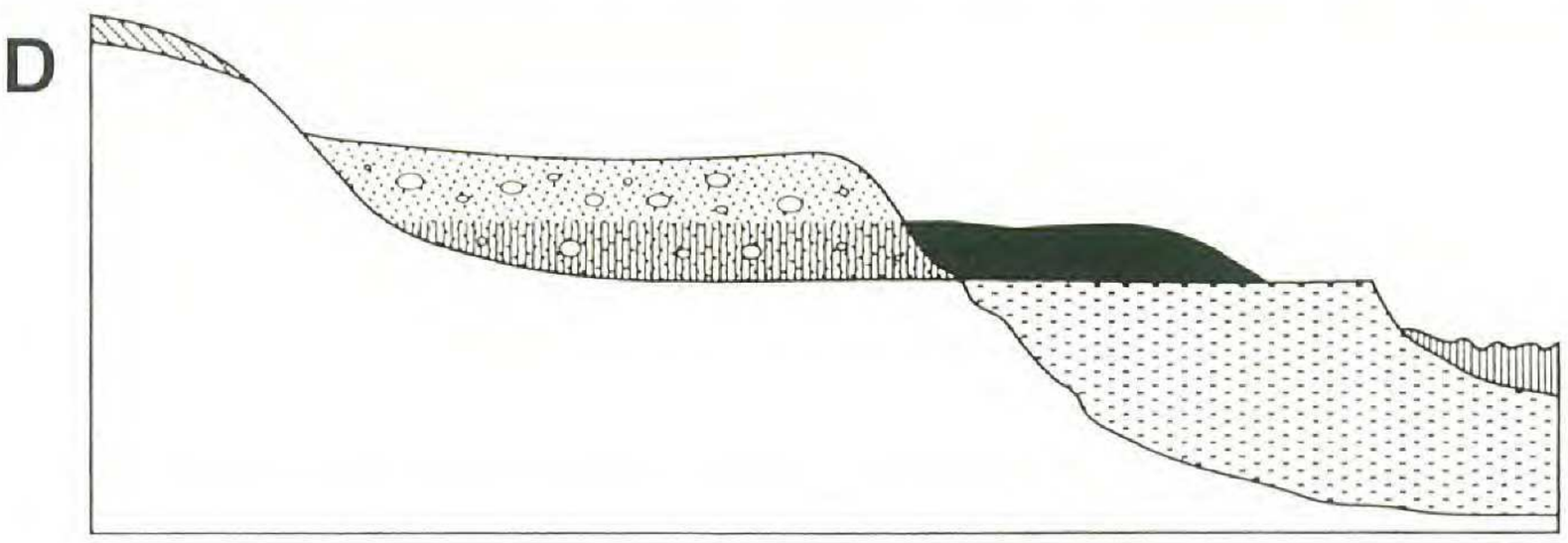

C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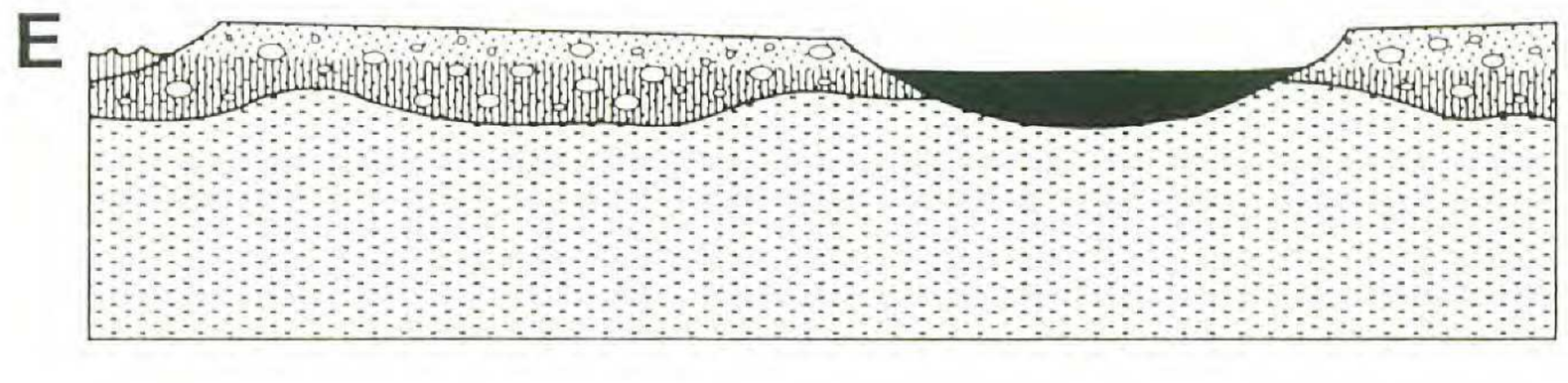
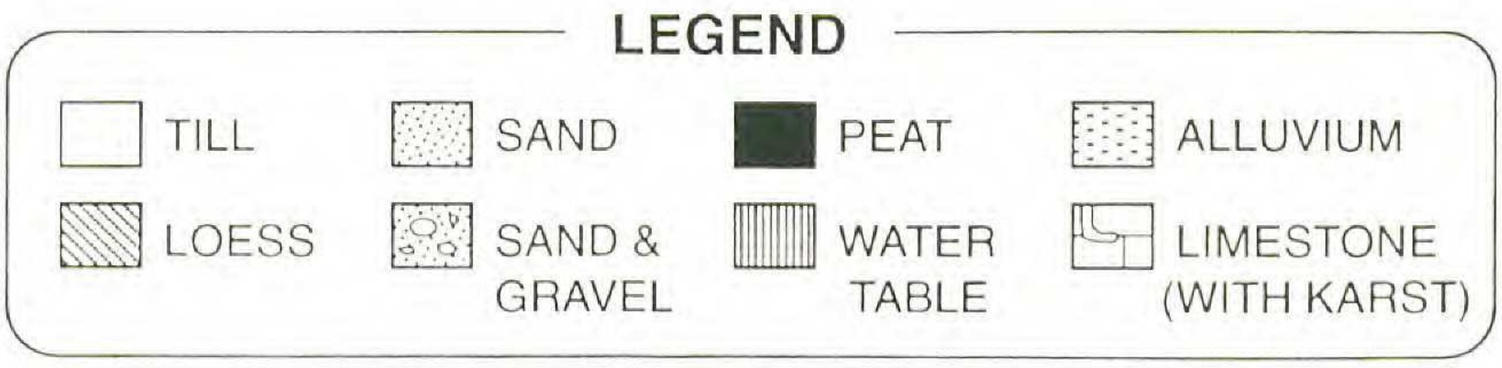

E


LEGEND
TILL
SAND
PEAT
ALLUVIUM
LOESS
SAND & GRAVEL
WATER TABLE
LIMESTONE (WITH KARST)

five broad groups based upon their underlying geology: pre-Illinoian till, bedrock, eolian sands, fluvial sands, and oxbows. These groups basically follow those of Thompson (1992) and Thompson et al. (1992), with the exception that (1) 'gravel ridge' sites have not been separated from other pre-Illinoian till sites as they simply represent pre-Illinoian till sites occurring in a more eroded landscape, and (2) sites developed in upland, eolian sands have been differentiated from those found with fluvially-deposited sands and gravels.

The most frequent geologic class of northeastern Iowa fens is associated with deposits of pre-Illinoian sand and gravel (Figure 3A). These 119 sites are found throughout the region (Figure 4) in association with water-bearing gravels deposited within and between tills (Thompson, 1992). The majority of pre-Illinoian till fens are found on footslopes along pediment margins (Hallberg et al., 1978), although they may occur at any position in the landscape where water-bearing gravels have been exposed.

Fens associated with bedrock aquifers (Figure 3B) are much less frequent (13 sites), and are restricted to the northeastern and northwestern parts of the study region (Figure 4) where most or all of the till was removed through periglacial processes. Like pre-Illinoian sites, bedrock fens are usually found on footslopes along pediment edges. While peat usually has formed in these fens, some sites have only minor peat accumulations, and have a soil surface consisting of cold, wet, limestone rubble. Such sites contain some of the most calcareous fen habitats found in the region.

Fens associated with eolian sands (14 sites) are restricted to the southern third of the region, with the majority being found along the Wapsipinicon and Cedar Rivers where extensive dune fields have formed in the surrounding uplands (Figure 4). Some eolian sand sites are also found along sand-mantled paha ridges distant from rivers (for an explanation of pahas see Prior, 1991). Eolian sand fens are often found along the base of dunes where the downward flow of water is stopped by more impervious tills or paleosols (Figure 3C). Many of these sites contain relatively low

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Figure 3. Idealized cross-section diagrams of the five classes of northeastern Iowa fens based on surficial geology. a: Pre-Illinoian till; b: Bedrock; c: Eolian Sand; d: Fluvial Sand; e: Oxbow.

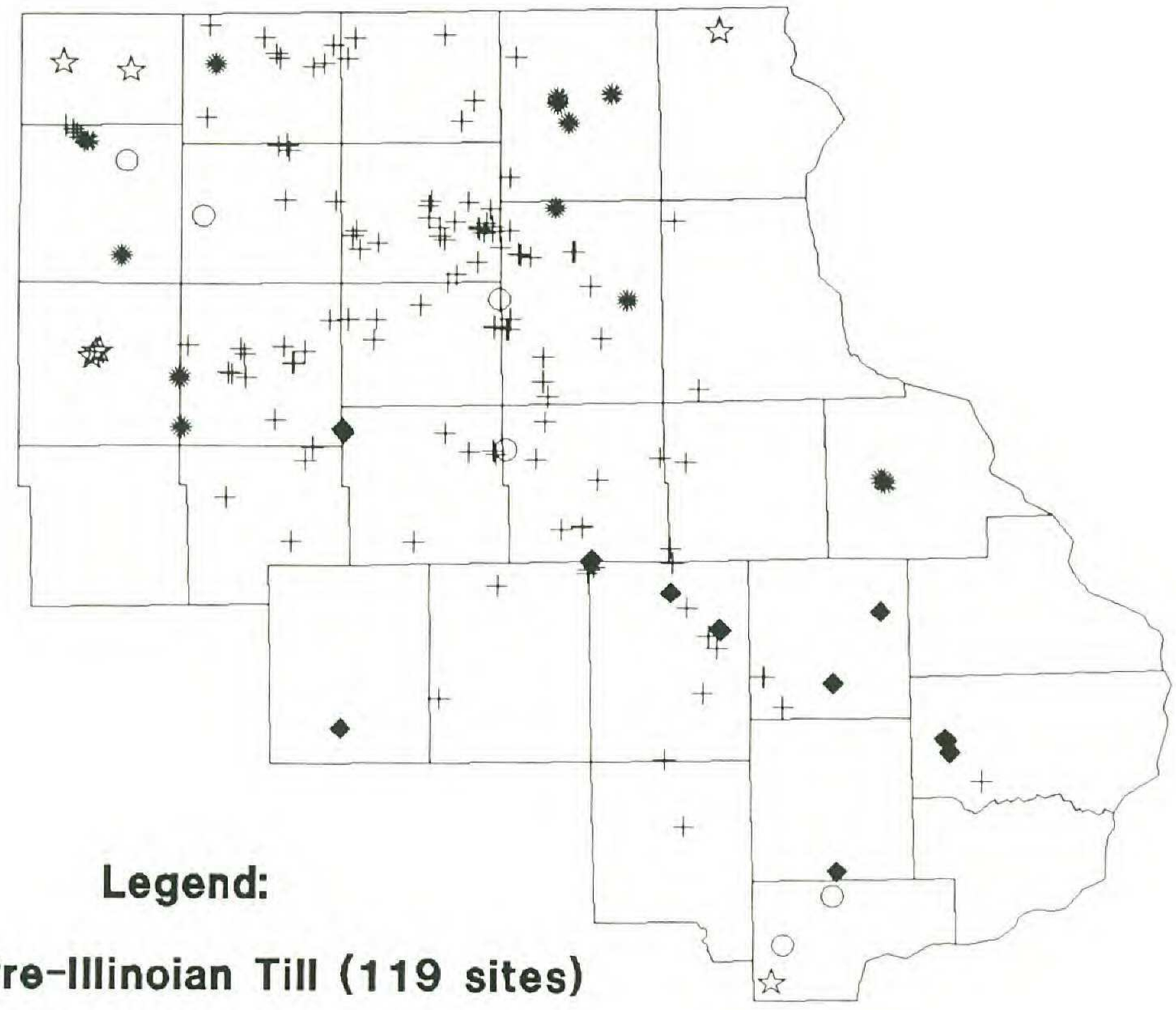

Figure 4. Distribution of the five geologic classes of northeastern Iowa fens.

amounts of organic matter and have margins consisting of wet, acidic sands. The lowest percent organic matter, pH, Ca, and Mg readings from eastern Iowa fens occur in these sites (see below).

Fens associated with fluvial sand and gravel terraces are rarer yet (8 sites). Fluvial sand fens occur when water moving through sands and gravels emerges to the surface along terrace margins (Figure 3D). While most of these sites are associated with outwash sands and gravels along the western section of the study region, three sites were found along the Upper Iowa and Cedar Rivers in Allamakee and Muscatine Counties (Figure 4). The largest single presettlement sites identified in the region by SCS maps occurred with fluvial sand and gravels along the Shell Rock and

Winnebago Rivers. Only a small part of a single one of these sites remained extant by 1991. Floristic lists from these sites prior to draining (Pammel, 1908, 1917) suggest that they once contained one of the most diverse fen floras in the state.

The most uncommon type of fen in northeastern Iowa are those formed from hydric succession of oxbow channels along abandoned stream meanders (6 sites). While oxbow channels typically have open water and would not support fen species, organic matter accumulation can continue until the soil surface becomes equivalent to the water table, creating the saturated but not inundated conditions necessary for colonization of fen species (Figure 3E). Fens occupying former oxbow channels are scattered throughout northeastern Iowa along the Winnebago, Cedar, Wapsipinicon, and Little Wapsipinicon Rivers (Figure 4). The greatest concentration of this fen type once occurred along the Cedar River south of Iowa City in the 'Lake Calvin Basin' where a number of successive oxbow lakes have formed fen habitats. Baker et al. (1987) have characterized the Holocene history of one of these sites through macrofossil and pollen analysis.

Geologic History

The landscapes upon which northeastern Iowa fens are found have formed through erosional processes within the last 20,000 years. The age of fen sites in this landscape was investigated by Thompson (1992), who determined the dates of the basal peat layer, using C_{14} isotope analysis, for ten sites. The age of basal peats in each of these sites were found to differ greatly, ranging between 10,900 and 2280 years B.P.

The interpretation of these dates is made more difficult by interruptions in peat deposition (sometimes accompanied by oxidized peat) within sites having the oldest basal dates (Hall, 1971; Van Zant and Hallberg, 1976). Fens without old (8000 year) basal peat dates are underlain by oxidized clay, till, or occasionally prairie soil (J. C. Nekola and R. G. Baker, unpubl. data). The existence of oxidized layers of peat or mineral soil underlying fen sites suggests that prior to modern peat development the site dried out, exposing the peats and underlying substrates to oxidation and erosion.

Fens in northeastern Iowa thus appear to be a Holocene phe-

Table 2. Comparison of means and standard deviations from soil chemistry variables between all surficial geology groups, and over all sites. Standard deviations are presented within parentheses under the mean for each group.

	Geologic Group					
Variable	Pre-Illinoian Till	Bedrock	Eolian Sand	Fluvial Sand	Oxbows	All
% Organic	40.9 (12.3)	26.5 (13.2)	18.8 (16.2)	29.1 (7.8)	35.5 (15.4)	37.0 (14.5)
pH	6.2 (.5)	6.6 (.6)	5.4 (.7)	6.8 (.3)	5.8 (.7)	6.2 (.6)
N	1.1 (1.3)	0.7 (.4)	0.8 (.6)	0.6 (.4)	0.6 (.3)	1.0 (1.7)
P	26.6 (14.6)	20.9 (15.8)	37.6 (13.1)	10.6 (9.2)	29.0 (13.0)	26.5 (15.0)
K	42.2 (17.6)	47.6 (23.6)	44.4 (22.6)	42.7 (7.4)	42.2 (18.9)	42.9 (18.2)
S	186.4 (140.1)	208.1 (159.7)	100.6 (69.7)	126.0 (78.9)	195.7 (98.7)	178.4 (135.2)
Ca	4494.4 (923.8)	4364.8 (996.1)	2101.1 (1038.1)	4507.1 (827.9)	3331.4 (1176.2)	4224.1 (1168.9)
Mg	411.2 (130.6)	560.5 (146.9)	220.7 (92.8)	480.1 (119.7)	339.9 (129.2)	406.6 (146.9)

nomenon, with the onset of development generally coinciding with the end of the Hypsithermal (Thompson, 1992). The creation of new sites has apparently continued until present, with some bedrock and eolian sand sites having less than eight cm of peat accumulation. A similar pattern has been found in the boreal fens

Table 3. Summary statistics from a 1-way ANOVA comparing the differences in soil chemistry variables across all geologic classes.

Soil Variable	*P*	r^2
% Organic	.000	.261
pH	.000	.210
N	.433	.024
P	.001	.110
K	.813	.010
S	.133	.044
Ca	.000	.345
Mg	.000	.238

of central Canada (Zoltai and Vitt, 1990) and pocosins of the southeastern Coastal plain (Daniel, 1981).

The implication for this post-Hypsithermal development of fen sites is that rare species which are found on them cannot be postulated to represent Pleistocene relicts. Rather, all of the rare taxa found in this community have had to disperse into this landscape within the last 6000 years.

Soil Chemistry

Variation of soil chemistry as a function of geology

The mean and standard deviation for eight soil chemistry variables within each of the five geologic classes of fens are presented in Table 2. The results of one-way ANOVA's on each of these variables (Table 3) demonstrate that three variables (N, K, and S) show no significant differences between the five geologic groups. The remaining five variables (percent organic matter, pH, P, Ca, and Mg) were found to possess significant differences across the geologic groups. Organic matter was highest in pre-Illinoian and oxbow fens, and was lowest in sites developed in eolian sands. Soil pH was highest on sites developed on bedrock and fluvial terrace sands, and was lowest in eolian sand and oxbow sites. Phosphorus content was highest in eolian sand and oxbow sites, and lowest in fluvial sand and bedrock sites. Calcium concentration was highest in pre-Illinoian till and bedrock sites, and was lowest in eolian sand sites. Lastly, soil magnesium was highest in bedrock sites, and was lowest in eolian sand sites.

Although significant differences were observed in the central tendency of values for these soil chemistry variables between geologic groups, this should not imply that there is little overlap between the soil chemistry variables for sites in differing geologic groups. For instance, while the mean percent organic matter of pre-Illinoian till sites was twice that of eolian sand fens (Table 3), 75% of sites in these two groups have soil Ca found in the range between the lowest recorded pre-Illinoian till (1900 ppm) and highest recorded eolian sand (4000 ppm) values. This fact is also demonstrated in the r^2 values for the significant ANOVA's which ranged between 11% for P to 35% for Ca, implying that

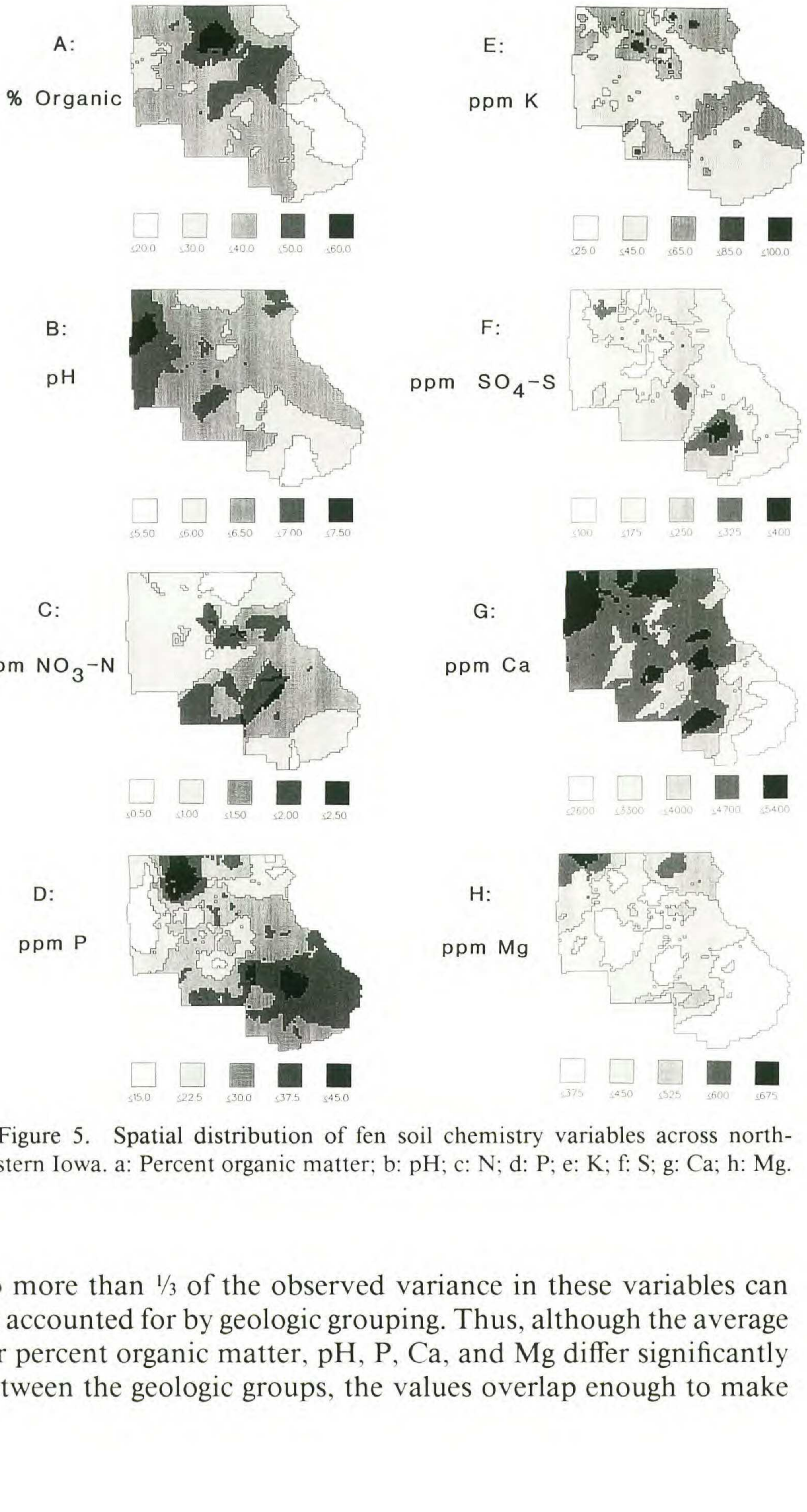

Figure 5. Spatial distribution of fen soil chemistry variables across northeastern Iowa. a: Percent organic matter; b: pH; c: N; d: P; e: K; f: S; g: Ca; h: Mg.

no more than ⅓ of the observed variance in these variables can be accounted for by geologic grouping. Thus, although the average for percent organic matter, pH, P, Ca, and Mg differ significantly between the geologic groups, the values overlap enough to make

it likely that any two sites will possess similar soil chemistry variables, independent of their surficial geology.

Variation in soil chemistry as a function of spatial location

How does soil chemistry vary in fen sites across the region? To address this question, kriged response surfaces for each of the eight soil variables were calculated for the study region (Figures 5A–5H). Relatively simple, approximately monotonic response surfaces were observed only in pH, organic matter, and Mg. The remaining soil chemistry variables have less clear spatial gradients as they possess multiple maxima and minima over the study region. The causes of all these gradients are undoubtedly complex, and related to climatic patterns (see below), and the non-random distribution of fens of differing geologic origin.

Climate

A final major class of environmental variation which defines the northeastern Iowa fen environment is climate, which will not only affect the distribution of species, but may also influence soil chemistry and the size and nature of groundwater aquifers.

Four major trends in climatic variation were identified over the study region through principal components analysis, accounting for 96% of the total variation. The first axis is related to temperature, and is most closely correlated with Average Yearly, Summer, Fall, and Spring Temperatures, Heat Stress Days/Year, Heat Stress Degrees/Year, Heating Degree Days, Cooling Degree Days, and Growing Degree Days. The variation of precipitation, exclusive of the summer months, represents a second major axis of variation. This axis is most closely correlated with Average Yearly, Winter, Spring and Fall Precipitation, Average Winter Temperature, and Maximum 24-hour Precipitation. The third major axis of climatic variation is represented by growing season, which is most closely correlated to 32°, 30°, 28°, 26°, and 24° Growing Seasons (in degrees Fahrenheit), and number of Freezing Days/Year. The last major climatic gradient is represented by Average Summer Precipitation. The spatial variation of each of these axes across the region was estimated by mapping the variable most highly correlated to each axis through block kriging (Figure 6A–6D).

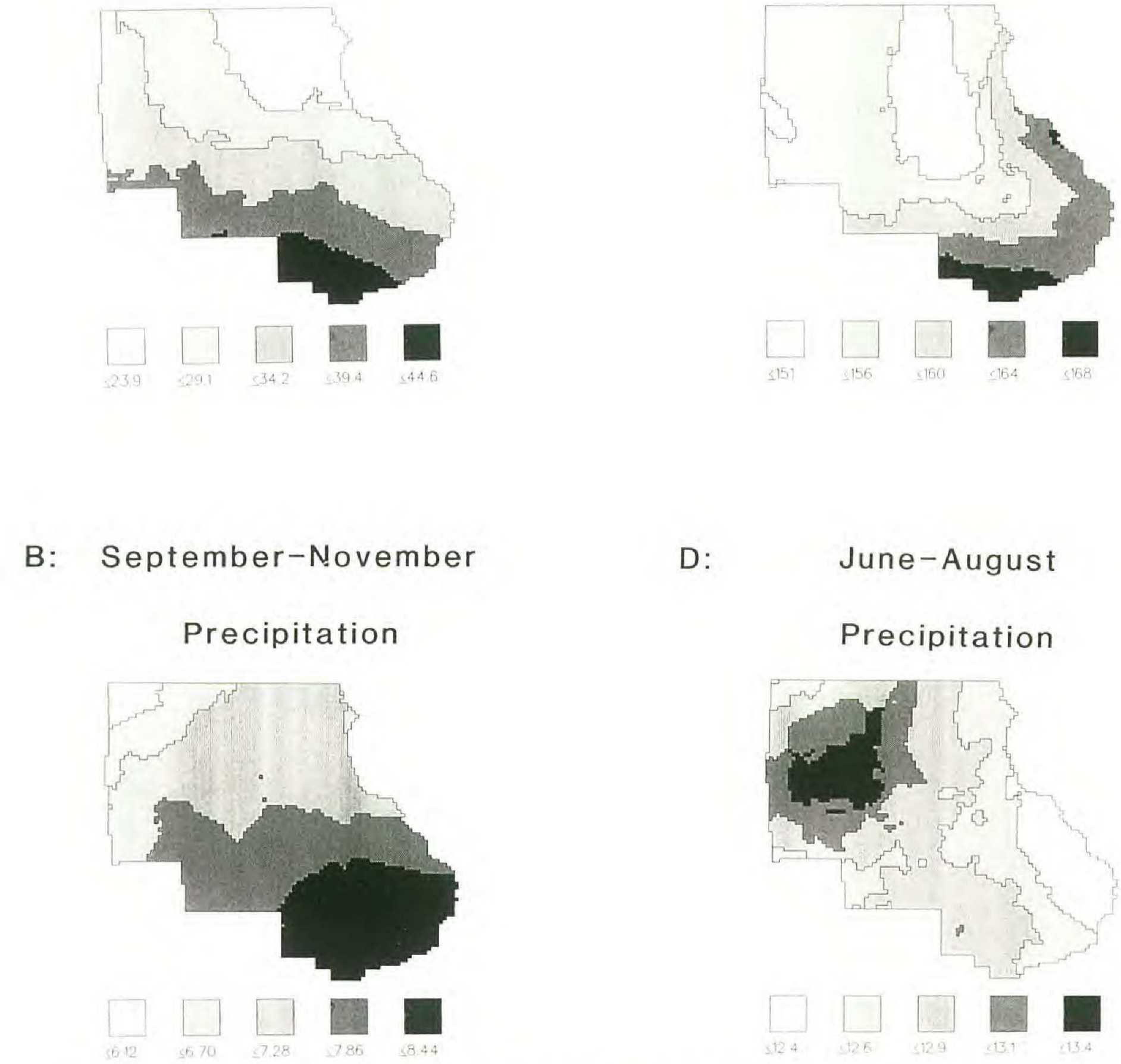

Figure 6. Spatial distribution of the main axes of climatic variation across northeastern Iowa, as represented by the variable most highly correlated with each axis. a: Temperature (as shown by Heat Stress Day/Year). b: Non-summer Precipitation (as shown by average fall (September–November) precipitation/year). c: Growing season (as shown by 32°F growing season). d: Summer (June–August) precipitation/year.

C. Biological Diversity of Northeastern Iowa Fen Habitats

Enumeration of the Vascular Flora

A total of 320 vascular plant taxa were recorded from northeastern Iowa fen communities (Appendix II). The flora includes approximately 23% which are incidental; their presence on fens

Table 4. Summary of the northeastern Iowa fen vascular plant flora in terms of major phylogenetic groups.

Division	Native Taxa			Exotic Taxa		
	Fen	Incid.	Tot.	Fen	Incid.	Tot.
Pteridophytes	10	5	15	0	0	0
Gymnosperms	0	1	1	0	0	0
Dicotyledons	145	49	194	4	4	8
Monocotyledons	84	13	97	3	2	5
Totals	239	68	307	7	6	13
Grand total						320

may be due to the mass effect (Shmida and Wilson, 1985) of surrounding communities. Only 13 taxa are exotic to northeastern Iowa, and almost half of these are incidental (Table 4). None of the exotic taxa at present is a threat to overall biodiversity on undisturbed sites, although some do invade disturbed areas.

The majority of the fen flora are dicotyledons, followed by monocotyledons, pteridophytes, and gymnosperms (Table 4). Of the families present in the fen flora, the two largest (in terms of taxa represented) are the Compositae and Cyperaceae, followed by the Gramineae, Salicaceae, Rosaceae, Labiatae, and Orchidaceae (Table 6). The best represented genera are *Carex, Salix, Aster, Cypripedium,* and *Solidago* (Table 5).

Table 5. Enumeration of the largest families and genera present in the northeastern Iowa fen vascular plant flora.

Families (7 or more taxa)		Genera (5 or more taxa)	
Name	Number of Taxa	Name	Number of Taxa
Compositae	41	*Carex*	27
Cyperaceae	40	*Salix*	14
Gramineae	27	*Aster*	6
Salicaceae	15	*Cypripedium*	6
Rosaceae	14	*Solidago*	6
Labiatae	13	*Galium*	5
Orchidaceae	13	*Gentiana*	5
Scrophulariaceae	9	*Juncus*	5
Leguminosae	8	*Viola*	5
Onagraceae	7		

Table 6. Summary of the number of rare vascular plants in the northeastern Iowa fen flora for different rarity classifications.

Source	Number	Percent of Total Flora	Percent of Native Flora
Native species rare on Iowan surface: based on Eilers (1971) and Cooperrider (1962)	97	30%	32%
Rare in Iowa: Howe et al. (1984)	63	20%	21%
Endangered in Iowa: Roosa et al. (1989)	21	7%	7%
Threatened in Iowa: Roosa et al. (1989)	11	3%	4%
Special concern in Iowa: Roosa et al. (1989)	6	2%	2%
New to Iowan surface: based on Eilers (1971) and Cooperrider (1962)	34	11%	11%
New to state	13	4%	4%
Total native rare taxa	134	44%	42%
Total exotic rare taxa	4	1%	

Stability and Distribution of the Vascular Plant Flora

Only seven taxa (*Carex diandra, Cassia marilandica, Eleocharis acicularis, Eriophorum gracile, Filipendula rubra, Salix lucida,* and *Selaginella eclipes*) which had been previously reported from northeastern Iowa fens were not located during the course of this study. Of these taxa, only *Carex diandra* is currently considered extirpated from the state (Howe et al., 1984). *Cassia marilandica, Filipendula rubra,* and *Selaginella eclipes* became extirpated from the northeastern Iowa fen flora through site destruction, while the remaining four have become extirpated through loss of populations on extant sites.

The distributions of most species seem relatively unaffected by the environmental variation described above. A few taxa should be pointed out, however, which do appear to be limited in their distribution by environmental factors. For example, one-half of the stations for *Menyanthes trifoliata* occur in oxbow fen sites, even though such sites represent only 4% of extant fens in the region. Some taxa, including *Angelica atropurpurea, Artemisia serrata, Lobelia kalmii,* and *Triglochin maritimum* are largely restricted to the northwestern portion of the study area where

precipitation tends to be lowest and soil pH, Ca, and Mg tend to be highest. Additional taxa, including *Botrychium multifidum, Botrychium simplex, Carex leptalea, Dryopteris ×uliginosa, Equisetum ×littorale, Eriophorum virginicum, Habenaria flava* var. *herbiola, Ludwigia palustris, Osmunda regalis, Panicum boreale, Rhexia virginica, Solidago patula, Viola lanceolata,* and *Viola primulifolia* are restricted to the south and southeast where they are usually found in low-pH, low-organic matter, low-Mg, and low-Ca eolian sand fens. This part of the study area also has the highest temperature and precipitation.

Rare Taxa in the Northeastern Iowa Fen Flora

A remarkable number of the taxa included in the flora of northeastern Iowa fens are rare in the region and state. Approximately 44% of the flora (138 taxa) fall into one of the five categories of rarity (Tables 6 and 7). Four of these are rare exotic weeds. Of the native taxa, 97 (30% of the flora) are rare in northeastern Iowa, 63 (20%) are rare in the state, 38 (12%) are listed by the Iowa DNR for Iowa Endangered Species Act protection, 34 (11%) are new to northeastern Iowa, and 13 (4%) are new to the state. Approximately 12% of all state rare taxa (Howe et al., 1984), and 17% of all Iowa 'endangered', 'threatened', and 'special concern' species (Roosa et al., 1989) occur in northeastern Iowa fen sites.

While certainly important for rare species, fens also contribute greatly to the total vascular plant biodiversity in the region and state. Even though fen habitats originally occupied approximately only .1% of the northeastern Iowa landscape (and currently cover less than .01% of the land surface), these sites harbor approximately 28% of the total flora of the Iowan Erosional Surface (based on estimates in Eilers, 1971) and 18% of the state's total flora (based on estimates from John Kartesz, pers. comm.).

CONCLUSIONS

Fens in northeastern Iowa represent a diverse collection of habitats which vary in their surficial geology, soils, and climate. These fen sites harbor a substantial proportion of both the total diversity of the Iowa flora and the rare components of that flora.

Of all the results presented above, perhaps none is more im-

Table 7. List of rare Iowa plants found in northeastern Iowa fens.

Taxon	Iowa Rare	New to NE Iowa	New to Iowa	DNR Rank
Alnus rugosa	x			
Angelica atropurpurea	x			SC
Artemesia serrata	x			
Aster junciformis	x			E
Aster puniceus	x			
Betula pumila var. *glandulifera*	x			SC
Betula × *sanbergii*		x	x	
Botrychium multifidum	x	x		E
Botrychium simplex	x			E
Cacalia suaveolens	x			T
Calamagrostis inexpansa		x		
Callitriche heterophylla	x			T
Carex diandra	x			
Carex frankii	x			
Carex granularis		x		
Carex lasiocarpa var. *ammericana*		x		
Carex leptalea	x	x		E
Carex prairea	x			
Carex rostrata var. *utriculata*	x			
Carex sartwellii	x			
Carex sterilis		x	x	
Carex tetanica	x			
Cirsium muticum	x			
Cornus stolonifera	x			
Cypripedium candidum	x			T
Cypripedium parviflorum		x	x	
Cypripedium pubescens	x			
Cypripedium reginae	x			E
Cypripedium × *andrewsii*	x	x		
Cypripedium × *favillianum*		x	x	
Cystopteris fragilis var. *fragilis*		x		
Dryopteris × *uliginosa*		x		
Eleocharis elliptica		x		
Eleocharis smallii		x		
Epilobium strictum		x	x	
Equisetum fluviatile	x			
Equisetum sylvaticum	x			E
Equisetum × *littorale*		x		
Eriophorum angustifolium				SC
Eriophorum gracile	x			E
Eriophorum virginicum		x	x	
Filipendula rubra	x			E
Galium labradoricum	x			E
Galium trifidum	x			
Gentiana crinita	x			

Table 7. Continued.

Taxon	Iowa Rare	New to NE Iowa	New to Iowa	DNR Rank
Gentiana crinita × *procera*		x	x	
Gentiana procera	x			T
Habenaria flava var. *herbiola*	x			E
Habenaria hyperborea	x	x		T
Habenaria praeclara	x			E
Habenaria psycodes	x			T
Hypericum majus	x			
Liatris ligulistylis	x			
Liparis loeselii	x			
Lobelia kalmii	x	x		T
Melanthium virginicum	x			
Menyanthes trifoliata	x			E
Mimulus glabratus var. *fremontii*	x			E
Muhlenbergia glomerata	x			
Ophioglossum vulgatum	x			SC
Osmunda regalis	x			E
Panicum boreale		x		E
Parnassia glauca	x			
Pilea fontana	x			
Rhexia virginica	x			E
Rhynchospora capillacea	x	x		T
Rubus pubescens	x	x		
Rumex orbiculatus	x			
Salix candida	x			SC
Salix lucida	x			E
Salix pedicellaris var. *hypoglauca*	x			T
Salix sericea	x	x		
Salix × *clarkei*		x	x	
Salix × *rubella*		x	x	
Salix × *subsericea*		x		
Salix × *cryptodonta*		x	x	
Salix candida × *pedicellaris*		x	x	
Scleria verticillata	x	x		E
Selaginella eclipes	x			E
Solidago patula	x			E
Solidago uliginosa		x	x	
Spiranthes lucida		x	x	E
Triadenum fraseri	x			
Triglochin maritimum	x	x		T
Triglochin palustre	x	x		T
Valeriana edulis	x			SC
Viola primulifolia	x			

portant than the wholesale destruction of this habitat, which had led to the loss of 93% of sites and of the complex spatial structure once present from township to regional scales. Sites are now more isolated than formerly, leading to an almost certain reduction in the rate of immigration between sites and in the rate (and direction of) migration of fen species across this landscape. It is essential that site isolation not increase further if fen species are to be given optimal chance of migration, as the past history of sites indicates that their habitats may not survive global warming.

Only 14 sites out of the 160 extant (Brayton-Horsley, Cutshall Access, Freeport, Elk Creek, Mark Sand Prairie, Nichols, Northwoods Park, Rowley, Rowley North, Slough Creek 1, Split Rock Park, Spring Creek 2, Wiese Slough, Worth Pond) are currently owned and protected by private or public conservation organizations. The remaining 146 sites are largely under private ownership. While most private landowners of fen sites have expressed interest in protecting their sites, a few are endangering sites. Since initiation of survey work, three sites (Grassley's Folly, Mark Sand South, and Temple Hill) have been badly damaged (and perhaps destroyed) through draining or grazing.

To protect the remaining biodiversity of this habitat, and to provide optimal migration ability for species in the event of climate change, all extant fens in northeastern Iowa must be afforded some form of protection, either through private landowner action or through the purchase of sites when they become endangered. It is essential that conservation organizations in the state make fen protection a priority to ensure that the physical and biological diversity documented here will be protected into the 21st century.

ACKNOWLEDGEMENTS

A number of people have been instrumental in this research and must be thanked. John and Gretchen Brayton suggested to me in 1984 the question of the diversity and extent of eastern Iowa peat 'bogs', and are in large part responsible for my interest in these sites. Bob Moats also played a critical role by showing me northwestern Iowa fens in the summer of 1985. Dick Baker, Willard Hawker, Louise McEarchen, John Nehnevaj, Dean Roosa, Arlan Kirchman, Dennis Schlicht, Bill Thomas, Robert Thomson, Dave Wendling, and Herb Wilson all provided me with locality information for extant fen sites, as well as able field as-

sistance. Fred Nekola provided invaluable support and field assistance throughout the project. Herb Wilson of the Soil Conservation Service furnished soil survey maps for all counties within the study region. Richard Carlson of the Department of Agronomy at Iowa State University kindly provided climatic data for Iowa. Dean Roosa and Terrence Frest helped finance field work during the 1988 season. The substantial financial support needed for completion of soil analyses was provided by the McElroy Foundation of Waterloo, Iowa. Field work was also funded in part through a National Science Foundation Graduate Fellowship. Peter White, Robert Peet, A. Linn Bogle, and Gordon DeWolf read and made useful comments regarding earlier drafts.

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APPENDIX I. INVENTORY OF EXTANT NORTHEASTERN IOWA FEN SITES.

Site Name	Size (ha)	Geologic class	Site Location
Allamakee County			
Clear Creek 1	1.3	F	NW¼ SE¼ NW¼ Sec. 27, T. 100 N, R. 5 W
Clear Creek 2	0.4	F	SW¼ NE¼ NW¼ Sec. 27, T. 100 N, R. 5 W
Benton County			
Boar Power	0.3	T	SE¼ NE¼ NE¼ Sec. 12, T. 86 N, R. 9 W
Elberon	1.2	T	SE¼ NW¼ Sec. 17, T. 83 N, R. 12 W
Gilchrist	1.8	T	SE¼ NW¼ SE¼ Sec. 12, T. 86 N, R. 9 W
Mt. Auburn	28.8	T	S½ NE¼ Sec. 23, T. 86 N, R. 11 W
Black Hawk County			
Dunkerton SE 1	12.1	T	SE¼ NE¼ NE¼ Sec. 11, T. 89 N, R. 11 W
Dunkerton SE 2	15.5	T	NW¼ SE¼ Sec. 2, T. 89 N, R. 11 W
Hammond Road	1.6	T	NE¼ NW¼ SE¼ Sec. 15, T. 87 N, R. 13 W
Mark Sand North	1.2	E	SW¼ NW¼ Sec. 19, T. 90 N, R. 14 W
Mark Sand South	3.6	E	S½ SE¼ SW¼ Sec. 19, T. 90 N, R. 14 W
St. Francis	0.4	T	NW¼ NW¼ NW¼ Sec. 8, T. 89 N, R. 11 W
St. John	6.3	T	NE¼ NW¼ Sec. 27, T. 90 N, R. 12 W
Bremer County			
Brayton-Horsley	4.7	T	N½ NW¼ SE¼ Sec. 2, T. 92 N, R. 11 W
Bushing	2.0	T	SW¼ NE¼ NW¼ Sec. 36, T. 93 N, R. 14 W
Frederika	0.9	T	NW¼ NE¼ SW¼ Sec. 13, T. 93 N, R. 13 W
Horsley	0.3	T	NW¼ SE¼ SE¼ Sec. 2, T. 92 N, R. 11 W
Northwoods Park	3.4	O	SW¼ NE¼ SE¼ Sec. 13, T. 93 N, R. 11 W
Plainfield	0.3	T	SE¼ NE¼ NE¼ Sec. 31, T. 93 N, R. 14 W
Waverly North	0.6	T	SE¼ NE¼ NE¼ Sec. 14, T. 92 N, R. 14 W
Buchanan County			
Amish	8.8	T	NW¼ NE¼ SW¼ Sec. 18, T, 90 N, R. 9 W
Cutshall Access	4.0	O	NE¼ NE¼ SW¼ Sec. 6, T. 89 N, R. 10 W
Masonville	1.0	T	SE¼ NE¼ NW¼ Sec. 13, T. 89 N, R. 7 W
Otterville	1.5	T	W½ NE¼ NE¼ Sec. 14, T. 89 N, R. 10 W
Rowley	2.2	T	NW¼ SE¼ SE¼ Sec. 2, T. 87 N, R. 9 W
Rowley North	0.1	T	NE¼ NE¼ SE¼ Sec. 2, T. 87 N, R. 9 W
Rowley West	6.7	T	SW¼ SE¼ SE¼ Sec. 5, T. 87 N, R. 9 W

APPENDIX I. Continued.

Site Name	Size (ha)	Geo-logic class	Site Location
Walker Sand Ridge North	0.5	E	SE¼ NW¼ SW¼ Sec. 31, T. 87 N, R. 8 W
Walker Sand Ridge South	0.9	E	SW¼ SW¼ SW¼ Sec. 31, T. 87 N, R. 8 W
Winthrop West	4.0	T	N½ SW¼ NW¼ Sec. 33, T. 89 N, R. 8 W
Butler County			
Allison East 1	1.4	T	SE¼ NE¼ SE¼ Sec. 35, T. 92 N, R. 16 W
Allison East 2	1.0	T	SW¼ NE¼ SE¼ Sec. 35, T. 92 N, R. 16 W
Allison East 3	2.7	T	NW¼ NE¼ SE¼ Sec. 35, T. 92 N, R. 16 W
Allison West	0.7	T	SW¼ NW¼ NE¼ Sec. 27, T. 92 N, R. 17 W
Austinville	0.1	B	SW¼ NW¼ NW¼ Sec. 19, T. 90 N, R. 18 W
Big Rock	1.5	T	NW¼ NE¼ NW¼ Sec. 22, T. 92 N, R. 16 W
Clarksville NE	0.9	T	NW¼ SE¼ NW¼ Sec. 35, T. 93 N, R. 15 W
Clarksville South	0.6	T	SW¼ SW¼ SE¼ Sec. 19, T. 92 N, R. 15 W
Dumont	1.2	T	SE¼ SE¼ SE¼ Sec. 18, T. 92 N, R. 18 W
Ft. Sumpter 1	7.7	T	S½ NW¼ NE¼ Sec. 8, T. 91 N, R. 17 W
Ft. Sumpter 2	0.8	T	SW¼ SW¼ SW¼ Sec. 5, T. 91 N, R. 17 W
Ft. Sumpter 3	7.3	T	SE¼ NW¼ SE¼ Sec. 10, T. 91 N, R. 17 W
New Albion	1.0	T	SE¼ SW¼ SW¼ Sec. 9, T. 90 N, R. 16 W
Pilot Rock	0.7	T	SE¼ SE¼ NE¼ Sec. 21, T. 92 N, R. 17 W
Cedar County			
Rochester South	0.9	E	SW¼ NE¼ SE¼ Sec. 25, T. 79 N, R. 3 W
Cerro Gordo County			
Buffalo Slough	12.6	O	E½ SW¼ NE¼ Sec. 34, T. 97 N, R. 20 W
Fertile	6.1	T	NE¼ NE¼ NW¼ Sec. 6, T. 97 N, R. 21 W
Neuhring	1.0	T	NE¼ NE¼ SW¼ Sec. 15, T. 97 N, R. 21 W
Pope	0.3	T	NE¼ SW¼ NW¼ Sec. 9, T. 97 N, R. 21 W
Rockwell	0.9	B	NW¼ SW¼ SW¼ Sec. 10, T. 94 N, R. 20 W
Wheelerwood	2.3	B	SE¼ SE¼ NE¼ Sec. 15, T. 97 N, R. 21 W
Winnebago 1	0.4	T	SW¼ NE¼ SE¼ Sec. 5, T. 97 N, R. 21 W
Winnebago 2	0.5	T	NW¼ SE¼ SE¼ Sec. 9, T. 97 N, R. 21 W
Chickasaw County			
Alpha East	0.3	T	SE¼ SE¼ SE¼ Sec. 1, T. 94 N, R. 11 W
Barker Station	1.2	T	NE¼ SW¼ SW¼ Sec. 25, T. 94 N, R. 12 W
Boyd	26.3	T	SE¼ NE¼ NE¼ Sec. 33, T. 95 N, R. 12 W
Boyd North	0.3	T	NW¼ SE¼ SE¼ Sec. 21, T. 95 N, R. 12 W
Boyd South	3.4	T	NE¼ NE¼ SW¼ Sec. 34, T. 95 N, R. 12 W
Bradford North	1.5	T	SE¼ SE¼ SE¼ Sec. 4, T. 94 N, R. 14 W
Chickasaw 1	18.4	T	SW¼ NW¼ SW¼ Sec. 28, T. 95 N, R. 14 W
Chickasaw 2	3.5	T	SE¼ NE¼ NW¼ Sec. 28, T. 95 N, R. 14 W
East Fork	3.1	T	NE¼ NW¼ SW¼ Sec. 5, T. 95 N, R. 12 W

APPENDIX I. Continued.

Site Name	Size (ha)	Geologic class	Site Location
Grassley's Folly	13.0	T	SW¼ SW¼ SW¼ Sec. 13, T. 95 N, R. 12 W
Kleiss	1.6	T	SW¼ SE¼ NE¼ Sec. 26, T. 95 N, R. 11 W
Lawler East	4.9	T	NE¼ NW¼ NW¼ Sec. 11, T. 95 N, R. 11 W
Lawler NW	20.3	T	SW¼ SW¼ SW¼ Sec. 32, T. 96 N, R. 11 W
Lawler SE	6.5	T	NW¼ NE¼ NE¼ Sec. 22, T. 95 N, R. 11 W
Marsh Creek	1.1	T	NE¼ NE¼ NW¼ Sec. 21, T. 94 N, R. 11 W
New Hampton East	36.7	T	S½ SE¼ SW¼ Sec. 8, T. 95 N, R. 12 W
New Hampton North	2.2	T	NW¼ SW¼ SE¼ Sec. 32, T. 96 N, R. 12 W
Simpson Creek 1	3.7	T	NE¼ SW¼ SE¼ Sec. 21, T. 95 N, R. 11 W
Simpson Creek 2	5.5	T	SW¼ NE¼ NE¼ Sec. 28, T. 95 N, R. 11 W
Simpson Creek 3	2.3	T	NE¼ NE¼ SW¼ Sec. 27, T. 95 N, R. 11 W
Split Rock	1.0	T	SW¼ SW¼ SW¼ Sec. 35, T. 94 N, R. 12 W
Stapleton Church	0.8	T	NW¼ SE¼ SE¼ Sec. 23, T. 95 N, R. 11 W
Two Mile Creek	1.8	T	SW¼ SW¼ SE¼ Sec. 36, T. 95 N, R. 14 W
Clayton County			
Postville	37.5	T	NW¼ Sec. 21, T. 95 N, R. 6 W
Strawberry Point	9.7	T	SW¼ NE¼ NW¼ Sec. 25, T. 91 N, R. 6 W
Clinton County			
Mockridge	0.2	E	SE¼ NW¼ NE¼ Sec. 36, T. 82 N, R. 1 E
Springeponde	8.3	T	NE¼ NW¼ SW¼ Sec. 23, T. 81 N, R. 2 E
Toronto 1	0.1	E	SE¼ SW¼ NW¼ Sec. 24, T. 82 N, R. 1 E
Toronto 2	1.3	E	NE¼ SE¼ NE¼ Sec. 23, T. 82 N, R. 1 E
Delaware County			
Hawker	7.3	T	NW¼ NE¼ NW¼ Sec. 22, T. 89 N, R. 6 W
Robinson	9.9	T	SE¼ NW¼ SW¼ Sec. 19, T. 87 N, R. 6 W
Dubuque County			
Epworth	0.2	B	SW¼ NE¼ SE¼ Sec. 4, T. 88 N, R. 1 W
Farley	0.2	B	NE¼ NW¼ NW¼ Sec. 4, T. 88 N, R. 1 W
Fayette County			
Alpha NW	2.7	T	NW¼ SE¼ NW¼ Sec. 29, T. 95 N, R. 10 W
Alpha SE 1	0.1	T	SW¼ SE¼ SE¼ Sec. 9, T. 94 N, R. 10 W
Alpha SE 2	6.1	T	NE¼ SE¼ SW¼ Sec. 9, T. 94 N, R. 10 W
Hawkeye	26.9	T	SW¼ SE¼ SW¼ Sec. 11, T. 94 N, R. 10 W
Hunter Creek	0.9	T	NE¼ SW¼ SE¼ Sec. 30, T. 91 N, R. 9 W
Oelwein West	4.3	T	E½ NE¼ SE¼ Sec. 13, T. 91 N, R. 10 W
Otter Creek	2.0	T	NW¼ NW¼ NW¼ Sec. 31, T. 92 N, R. 9W
Smithfield Township Hall	3.5	T	SW¼ SE¼ NE¼ Sec. 16, T. 92 N, R. 8 W

APPENDIX I. Continued.

Site Name	Size (ha)	Geo-logic class	Site Location
St. Lucas	2.4	B	S½ SW¼ SW¼ Sec. 4, T. 95 N, R. 9 W
Sumner SE 1	6.4	T	NE¼ SE¼ SE¼ Sec. 6, T. 92 N, R. 10 W
Sumner SE 2	2.6	T	NE¼ SW¼ SE¼ Sec. 6, T. 92 N, R. 10 W
Sumner SE 3	0.6	T	SW¼ SE¼ NW¼ Sec. 32, T. 93 N, R. 10 W
Turner Creek 1	2.1	T	N½ NW¼ SE¼ Sec. 11, T. 94 N, R. 9W
Turner Creek 3	0.2	T	NE¼ NE¼ SE¼ Sec. 11, T. 94 N, R. 9 W
Wadena NW	0.8	B	NW¼ SE¼ SE¼ Sec. 18, T. 93 N, R. 7 W
West Union South	7.1	T	SW¼ NE¼ SW¼ Sec. 5, T. 93 N, R. 8 W
Floyd County			
Charles City East	10.0	T	NE¼ SW¼ SW¼ Sec. 36, T. 96 N, R. 15 W
Charles City West	0.5	T	NW¼ NE¼ SE¼ Sec. 34, T. 96 N, R. 16 W
Rockford	2.3	O	NE¼ NE¼ SW¼ Sec. 10, T. 95 N, R. 18 W
Slough Creek 1	9.3	T	NE¼ SW¼ NE¼ Sec. 21, T. 97 N, R. 16 W
Slough Creek 2	0.8	T	NE¼ NE¼ NE¼ Sec. 22, T. 97 N, R. 16 W
Slough Creek 3	1.0	T	SE¼ NE¼ NE¼ Sec. 22, T. 97 N, R 16 W
Slough Creek 4	1.2	T	NW¼ SE¼ NE¼ Sec. 22, T. 97 N, R. 16 W
Slough Creek 5	4.9	T	NW¼ NE¼ NW¼ Sec. 26, T. 97 N, R. 16 W
Franklin County			
Maynes Creek	1.0	B	NW¼ NE¼ SE¼ Sec. 12, T. 91 N, R. 19 W
Spring Creek 1	11.9	F	NE¼ NW¼ SE¼ Sec. 26, T. 92 N, R. 21 W
Spring Creek 2	0.8	F	SE¼ NE¼ SE¼ Sec. 24, T. 92 N, R. 21 W
Spring Creek 3	1.3	F	NW¼ SE¼ SW¼ Sec. 24, T. 92 N, R. 21 W
Grundy County			
Morrison	1.6	T	N½ SE¼ NW¼ Sec. 15, T. 87 N, R. 16 W
New Hartford	1.4	T	NE¼ NW¼ NE¼ Sec. 5, T. 89 N, R. 15 W
Stout	0.6	T	SW¼ NW¼ NE¼ Sec. 18, T. 89 N, R. 15 W
Wellsburg	4.1	T	NW¼ NW¼ SE¼ Sec. 12, T. 88 N, R. 18 W
Howard County			
Lime Springs	1.8	T	SW¼ SE¼ NE¼ Sec. 27, T. 100 N, R. 12 W
Riceville North	1.2	T	SW¼ SW¼ SW¼ Sec. 8, T. 99 N, R. 14 W
Schley	21.5	T	W½ SW¼ NW¼ Sec. 16, T. 98 N, R. 11 W
Staff Creek	2.4	T	NW¼ SE¼ SW¼ Sec. 28, T. 100 N, R. 14 W
Turkey River	8.5	T	NW¼ NE¼ SW¼ Sec. 31, T. 98 N, R. 11 W
Johnson County			
Coralville	0.2	T	SE¼ NE¼ SE¼ Sec. 20, T. 80 N, R. 6 W
Jones County			
Olin	2.1	E	NW¼ SW¼ SE¼ Sec. 6, T. 83 N, R. 2 W
Temple Hill	0.3	E	NE¼ NW¼ NE¼ Sec. 17, T. 85 N, R. 1 W

APPENDIX I. Continued.

Site Name	Size (ha)	Geo-logic class	Site Location
Walnut Creek 1	0.8	T	NE¼ NE¼ SE¼ Sec. 32, T. 84 N, R. 4 W
Walnut Creek 2	1.1	T	SE¼ NW¼ SW¼ Sec. 33, T. 84, N, R. 4 W
White Oak Creek	1.0	T	NE¼ SE¼ NE¼ Sec. 26, T. 83 N, R. 4 W
Linn County			
Central City	0.3	T	NE¼ NW¼ NE¼ Sec. 9, T. 85 N, R. 6 W
Loupee	15.9	T	E½ NE¼ NE¼ Sec. 14, T. 83 N, R. 6 W
Matus	18.5	T	SE¼ NE¼ Sec. 36, T. 85 N, R. 6 W
Moses Road	0.2	T	NW¼ SE¼ SE¼ Sec. 6, T. 86 N, R. 8 W
Paris	1.1	E	SE¼ NW¼ SW¼ Sec. 30, T. 86 N, R. 6 W
Patton	0.8	T	E½ NW¼ NE¼ Sec. 6, T. 86 N, R. 6 W
Western College	0.6	T	SE¼ NE¼ SE¼ Sec. 35, T. 82 N, R. 7 W
Whittier	1.6	T	NE¼ SW¼ NW¼ Sec. 8, T. 84 N, R. 5 W
Windy Oaks North	0.4	E	SW¼ SE¼ NE¼ Sec. 29, T. 85 N, R. 5 W
Windy Oaks South	0.6	E	NW¼ SW¼ NE¼ Sec. 29, T. 85 N, R. 5 W
Mitchell County			
Little Cedar	0.7	T	SW¼ SE¼ SE¼ Sec. 9, T. 99 N, R. 16 W
McIntire	0.5	T	SE¼ SE¼ SE¼ Sec. 35, T. 100 N, R. 15 W
Osage West	12.4	T	NE¼ NW¼ NE¼ Sec. 34, T. 98 N, R. 18 W
Mona	1.4	T	SW¼ SE¼ SW¼ Sec. 14, T. 100 N, R. 18 W
Riceville NW	2.1	T	SW¼ SE¼ Sec. 15, T. 99 N, R. 15 W
St. Ansgar	2.0	B	NW¼ SW¼ SW¼ Sec. 13, T. 99 N, R. 18 W
Stacyville North	2.4	T	NW¼ SW¼ SE¼ Sec. 30, T. 100 N, R. 16 W
Stacyville SE	0.5	T	N½ SE¼ NW¼ Sec. 9, T. 99 N, R. 16 W
Stone School	1.1	T	NW¼ SE¼ NE¼ Sec. 20, T. 99 N, R. 15 W
Muscatine County			
Conesville	3.0	F	SE¼ NE¼ NE¼ Sec. 20, T. 76 N, R. 4 W
Nichols	49.3	O	NW¼ SE¼ Sec. 23, T. 77 N, R. 4 W
Wiese Slough	19.9	O	E½ SE¼ NE¼ Sec. 13, T. 78 N, R. 3 W
Tama County			
Sand Hill	0.4	E	NE¼ NW¼ SE¼ Sec. 2, T. 82 N, R. 15 W
Winneshiek County			
Dry Run	3.9	B	SE¼ NE¼ SW¼ Sec. 35, T. 98 N, R. 9 W
Freeport	1.4	B	NE¼ NE¼ NE¼ Sec. 14, T. 98 N, R. 8 W
Jackson Junction	1.4	T	NE¼ SW¼ NE¼ Sec. 20, T. 96 N, R. 10 W
Kendallville South	5.1	T	NW¼ SW¼ SE¼ Sec. 9, T. 99 N, R. 10 W
Madison Church 1	2.8	B	SW¼ NE¼ NE¼ Sec. 16, T. 98 N, R. 9 W

APPENDIX I. Continued.

Site Name	Size (ha)	Geo-logic class	Site Location
Madison Church 2	4.6	B	SE¼ NW¼ NE¼ Sec. 21, T. 98 N, R. 9 W
Worth County			
Elk Creek	2.1	F	SW¼ SE¼ NW¼ Sec. 18, T. 99 N, R. 21 W
Worth Pond	50.1	F	SW¼ NE¼ NW¼ Sec. 26, T. 99 N, R. 20 W

Legend for geologic classes: T = pre-Illinoian till site, B = Bedrock site, E = Eolian sand site; F = Fluvial sand site, O = Oxbow site.

APPENDIX II: ANNOTATED CATALOGUE OF VASCULAR PLANT SPECIES FROM NORTHEASTERN IOWA FENS

This annotated catalogue is based on collections and observations made from 1984 to 1991 by J. C. Nekola, and from a survey of the northeastern Iowa botanical literature as detailed under Methods. The nomenclature follows that of Swink and Wilhelm (1979). Where names differ from those of Kartesz (1993), the Kartesz synonym follows in brackets. Following each binomial is a common name, rarity in the northeastern Iowa and entire Iowa flora [using the following abbreviations:

R = Rare in Iowan Erosional surface (Cooperrider, 1962; Eilers, 1971);
L = Listed as rare Iowa plant by Howe et al. (1984);
E = Listed as Endangered by Roosa et al. (1989);
T = Listed as Threatened by Roosa et al. (1989);
SC = Listed as Special Concern by Roosa et al. (1989);
NI = New to Iowan Surface flora (Cooperrider, 1962; Eilers, 1971);
NS = New to state flora]

Taxa incidental in the fen flora are also noted, as is an approximation of the distribution and frequency of each taxa across this region. For selected rare taxa, the number of sites of occurrence is recorded. All exotic taxa are preceded by an '*'.

PTERIDOPHYTES

Equisetaceae

Equisetum arvense L. (Field Horsetail): Incidental. Infrequent throughout on margins.

Equisetum fluviatile L. (Water Horsetail): R, L Scattered throughout. (14 sites)

Equisetum sylvaticum L. (Wood Horsetail): R, L, E Incidental. Rare in extreme north on margins. (1 site)

Equisetum ×*littorale* Kuhlewein ex Rupr.: Rare in extreme east on an eolian sand fen. (1 site)

Ophioglossaceae

Botrychium multifidum (Gmel.) Trev. (Leathery Grape Fern): NI, L, E Incidental. Rare on sandy margins in south central. (2 sites)
Botrychium simplex E. Hitchc. (Small Grape Fern): R, L, E Incidental. Rare on a sandy margin in the south central. (1 site)
Ophioglossum vulgatum L. [*O. pusillim* Raf.] (Adder's Tongue Fern): R, L, SC Scattered in central. (13 sites)

Osmundaceae

Osmunda regalis L. var. *spectabilis* (Willd.) Gray (Royal Fern): R, L, E Incidental. Rare in southeast on moist margins of eolian sand and oxbow fens. (3 sites)

Polypodiaceae
(including *Dryopteraceae, Thelypteraceae*)

Athyrium filix-femina (L.) Roth (Lady Fern): Frequent in east-central.
Cystopteris fragilis (L.) Bernh. var. *fragilis* (Fragile Fern): NI Rare in north. (1 site)
Dryopteris cristata (L.) Gray (Crested Shield Fern): R Frequent in eastern half. (26 sites)
Dryopteris ×*uliginosa* (A. Braun ex Dowell) Druce: NI Rare on a margin in the extreme south. (1 site)
Onoclea sensibilis L. (Sensitive Fern): Abundant and dominant throughout.
Thelypteris palustris Schott (Marsh Fern): Abundant and dominant throughout.

Selaginellaceae

Selaginella eclipes Buck (Northern Marsh Spike Moss): R, L, E Reported (and apparently extirpated) from a single site in Muscatine County (Guldner, 1960). Although known from a calcareous depression in Worth County (Nekola, 1991), no extant fen populations have been observed.

GYMNOSPERMS

Cupressaceae

Juniperus virginiana L. (Red Cedar): Incidental. Uncommon throughout on dry hummocks and margins.

DICOTYLEDONS

Aceraceae

Acer negundo L. (Box Elder): Incidental. Uncommon throughout in thickets and on margins.
Acer saccharinum L. (Silver Maple): Incidental. Rare on margins.

Anacardiaceae

Rhus radicans L. [*Toxicodendron radicans* (L.) Kuntze] (Poison Ivy): Incidental. Rare on margins.

Apocynaceae

Apocynum sibiricum Jacq. [*A. cannabinum* L.] (Indian Dogbane): Incidental. Uncommon throughout.

Asclepiadaceae

Asclepias incarnata L. (Swamp Milkweed): Common throughout.
Asclepias syriaca L. (Common Milkweed): Incidental. Scattered throughout on margins.

Balsaminaceae

Impatiens capensis Meerb. (Spotted Jewelweed): Common throughout in discharge zones.
Impatiens pallida Nutt. (Pale Jewelweed): Rare in discharge zones.

Betulaceae

Alnus rugosa (Regel) Fern. [*Alnus incana* (L.) Moench ssp. *rugosa* (DuRoi) Clausen] (Speckled Alder): L Uncommon in north central, where it is locally dominant. (5 sites)
Betula pumila L. var. *glandulifera* Regel (Bog Birch): R, L, SC Locally common in north central. (20 sites)
Betula ×*sandbergii* Britt. (Sandberg's Birch): NI, NS Rare in north central. (1 site)

Callitrichaceae

Callitriche heterophylla Pursh (Large Water Starwort): R,L,T Incidental. Rare in cold water of discharge streams. (2 sites)

Campanulaceae

Campanula aparinoides Pursh (Marsh Bellflower): Abundant throughout.
Lobelia kalmii L. (Kalm's Lobelia): NI, L, T Rare in northwest on low vegetation mats. (4 sites)
Lobelia siphilitica L. (Great Blue Lobelia): Frequent throughout.

Caprifoliaceae

Sambucus canadensis L. (Elderberry): Infrequent throughout in thickets.
Viburnum lentago L. (Nannyberry): Infrequent throughout in thickets.

Caryophyllaceae

Arenaria lateriflora L. [*Moehringia lateriflora* (L.) Fenzl.] (Wood Sandwort): Incidental. Uncommon in eastern counties.

**Cerastium vulgatum* L. [*Cerastium fontanum* Baumg. ssp. *vulgare* (Hartman) Greuter & Burdet] (Mouse-eared Chickweed): Incidental. Throughout on heavily grazed margins.

Silene nivea (Nutt.) Muhl. ex Otth. (Snowy Campion): R Scattered in southern third.

Stellaria longifolia Muhl. ex Willd. (Stitchwort): Frequent in eastern half.

Compositae

Achillea millefolium L. (Yarrow): Dry hummocks and margins throughout.

Ambrosia artemisiifolia L. (Common Ragweed): Incidental. Rare on dry hummocks.

Ambrosia trifida L. (Giant Ragweed): Locally dominant throughout on disturbed soil.

Artemisia serrata Nutt. (Saw-toothed Sage): L Uncommon on margins in northwest. (5 sites)

Aster ericoides L. (Heath Aster): Incidental. Throughout on dry hummocks.

Aster junciformis Rydb. [*A. borealis* (Torr. & Gray) Prov.] (Rush Aster): R, L, E Rare in north third on cold, wet soil. (4 sites)

Aster novae-angliae L. (New England Aster): Frequent throughout.

Aster praealtus Poir. (Willow Aster): Scattered in east half.

Aster puniceus L. (Swamp Aster): L Abundant throughout. (152 sites)

Aster umbellatus P. Mill. (Flat-top Aster): Common throughout. Most material is referable to the doubtfully distinct *Aster pubentior* Cronq.

Bidens cernua L. (Nodding Bur Marigold): Uncommon throughout on exposed peat.

Bidens coronata (L.) Britt. R (Tall Swamp Marigold): Frequent throughout.

Bidens frondosa L. (Common Beggar's Ticks): Uncommon on disturbed soils.

Boltonia asteroides (L.) L'Her. (False Aster): Common throughout.

Cacalia suaveolens L. [*Synosma suaveolens* (L.) Raf. ex Britt.] (Sweet Indian Plantain): R, L, T Scattered and rare on margins and shrub thickets. (2 sites)

Cirsium altissimum (L.) Hill (Tall Thistle): R Incidental. Scattered on disturbed soils.

**Cirsium arvense* (L.) Scop. (Canadian Thistle): Incidental. Infrequent on disturbed margins.

Cirsium discolor (Muhl. ex Willd.) Spreng. (Pasture Thistle): Incidental. Infrequent on margins.

Cirsium muticum Michx. (Swamp Thistle): R, L Common in northwest, rare and scattered elsewhere. (30 sites)

Erechtities hieraciifolia (L.) Raf. ex DC. (Fireweed): R Scattered throughout on exposed peat.

Eupatorium maculatum L. (Spotted Joe-pye Weed): Common throughout.

Eupatorium perfoliatum L. (Common Boneset): Frequent throughout on mineral-rich soil.

Eupatorium rugosum Houtt. [*Ageratina altissima* (L.) King & H. E. Robins. var. *altissima*] (White Snakeroot): Incidental. Rare in south.
Helenium autumnale L. (Sneezeweed): Common throughout. One of the most conspicuous late-summer flowering plants.
Helianthus grosserratus Martens (Sawtooth Sunflower): Common throughout, becoming most abundant on disturbed areas.
Lactuca canadensis L. (Wild Lettuce): Incidental. Infrequent on margins.
Liatris ligulistylis (Nels.) Schum. (Northern Blazingstar): R, L Incidental. Rare in northwest on margins.
Liatris pycnostachya Michx. (Prairie Blazingstar): Uncommon in north half.
Rudbeckia hirta L. (Black-eyed Susan): Abundant throughout.
Senecio aureus L. (Golden Ragwort): R Frequent locally in northern half.
Senecio pauperculus Michx. (Common Ragwort): Incidental. Rare on dry hummocks on margins.
Silphium perfoliatum L. (Cup Plant): Incidental. Rare on margins.
Solidago altissima L. [*S. canadensis* L.] (Tall Goldenrod): Abundant throughout. Increases in dominance with disturbance.
Solidago gigantea Ait. (Late Goldenrod): Scattered throughout north half.
Solidago graminifolia (L.) Salisb. [*Euthamia graminifolia* (L.) Nutt.] (Grass-leaved Goldenrod): Common throughout.
Solidago patula Muhl. ex Willd. R, L, E (Broad-leaved Goldenrod): Rare in extreme south. (1 site)
Solidago riddellii Frank ex Riddell (Riddell's Goldenrod): R Frequent throughout, but less common in southeast. (62 sites)
Solidago uliginosa Nutt. (Bog Goldenrod): NI, NS Rare in northeast. (2 sites)
**Sonchus asper* (L.) Hill. (Sow Thistle): R Rare on disturbed areas throughout.
**Taraxacum officinale* Weber (Common Dandelion): Frequent throughout. This is the most frequently encountered exotic species.
Vernonia fasciculata Michx. (Common Ironweed): Frequent throughout on margins.

Convolvulaceae
(including *Cuscutaceae*)

Convolvulus sepium L. [*Calystegia sepium* (L.) R. Br.] (Hedge Bindweed): Incidental. Rare on margins.
Cuscuta cephalanthi Engelm. (Buttonbush Dodder): R Infrequent on tall herbaceous plants.

Cornaceae

Cornus alternifolia L. f. (Alternate-leaved Dogwood): Incidental. Rare in thickets.
Cornus obliqua Raf. [*C. amomum* P. Mill. ssp. *obliqua* (Raf.) J. S. Wilson] (Pale Dogwood): Frequent throughout in thickets.
Cornus stolonifera Michx. [*C. sericea* L. ssp. *sericea*] (Red-osier Dogwood): R, L Scattered throughout, but most common in north half in thickets.

Cruciferae

Cardamine bulbosa (Schreb. ex Muhl.) BSP (Bulbous Cress): Abundant throughout.

**Nasturtium officinale* R. Br. [*Rorippa nasturtium-aquaticum* (L.) Hayek] (Water Cress): R Scattered throughout in cold, flowing water of discharge streams.

Cucurbitaceae

Echinocystis lobata (Michx.) T. & G. (Wild Cucumber): Incidental. Rare vine of thickets.

Euphorbiaceae

Acalypha rhomboidea Raf. [*A. virginica* L. var. *rhomboidea* (Raf.) Cooperrider] (Three-seeded Mercury): Frequent throughout on dry hummocks.

Gentianaceae

Gentiana andrewsii Griseb. (Bottle Gentian): Common throughout.

Gentiana crinita Froel. [*Gentianopsis crinita* (Froel) Ma] (Large Fringed Gentian): R, L Locally common in south half. (34 sites)

Gentiana procera Holm [*Gentianopsis procera* (Holm) Ma] (Small Fringed Gentian): R, L, T Locally common in north half. (21 sites)

Gentiana quinquefolia L. [*Gentianella quinquefolia* (L.) Sm.] (Stiff Gentian): Scattered throughout.

Gentiana crinita Froel. × *Gentiana procera* Holm: NI, NS Rare in north central. (1 site)

Hypericaceae

Hypericum majus (Gray) Britt. (Small St. John's Wort): L Scattered throughout on hummocks and disturbed soil.

Hypericum punctatum Lam. (Spotted St. John's Wort): Incidental. Rare in margins.

Hypericum pyramidatum Ait. [*Hypericum ascyron* L.] (Great St. John's Wort): Frequent in east half.

Hypericum sphaerocarpum Michx. (Round-fruited St. John's Wort): Scattered throughout.

Triadenum fraseri (Spach) Gl. (Marsh St. John's Wort): R, L Locally common except in northwest. (54 sites)

Labiatae

Lycopus americanus Muhl. ex W. Bart. (Common Water Horehound): Abundant throughout.

Lycopus uniflorus Michx. (Northern Bugleweed): Less common, but found throughout.

Lycopus virginicus L. (Bugleweed): R Scattered throughout.

Mentha arvensis L. (Wild Mint): Scattered throughout.
Monarda fistulosa L. (Wild Bergamot): Incidental. Frequent on margins.
Physostegia virginiana (L.) Benth. (Obedient Plant): Scattered throughout.
**Prunella vulgaris* L. (Self Heal): Incidental. Throughout on margins, dry hummocks and disturbed, dry soil.
Pycnanthemum virginianum (L.) Durant & Jackson ex B. L. Robins & Fern. (Common Mountain Mint): Abundant throughout.
Scutellaria galericulata L. (Marsh Skullcap): R Frequent in south half, scattered elsewhere. (33 sites)
Scutellaria lateriflora L. (Mad-dog Skullcap): Uncommon on margins.
Stachys palustris L. (Woundwort): Frequent.
Stachys tenuifolia Willd. (Smooth Hedge Nettle): Occasional in south half.
Teucrium canadense L. (Wild Germander): Rare in east central.

Leguminosae

Amorpha fruticosa L. (Indigo Bush): Occasional in east half in shrub thickets.
Amphicarpa bracteata (L.) Fern. (Hog Peanut): Incidental. Rare on margins.
Apios americana Medik. (Ground Nut): R Incidental. Rare on margins.
Cassia marylandica L. [*Senna marilandica* (L.) Link] (Wild Senna): R Incidental? Reported from a single, destroyed Muscatine County site (Guldner, 1960).
Desmodium canadense (L.) DC. (Showy Tick Trefoil): Incidental. Scattered on dry hummocks and margins.
Lathyrus palustris L. (Marsh Vetchling): Common throughout.
Lathyrus venosus Muhl. ex Willd. (Veiny Pea): Incidental. Rare on dry margins.
Strophostyles helvula (L.) Ell. (Trailing Wild Bean): Incidental. Rare on dry margins.

Lythraceae

Lythrum alatum Pursh (Winged Loosestrife): Abundant throughout. Often reaches highest dominance in zones of low vegetation.

Melastomataceae

Rhexia virginica L. (Meadow Beauty): R, L, E Incidental. Rare on an eastern eolian sand site, in proximity to a vernal pool. (1 site)

Menyanthaceae

Menyanthes trifoliata L. (Buckbean): R, L, E Uncommon throughout, preferring very wet soil. (6 sites)

Oleaceae

Fraxinus nigra Marsh. (Black Ash): Incidental. Occasional in shrub thickets and dry margins.

Onagraceae

Epilobium coloratum Biehler (Cinnamon Willow Herb): Frequent throughout.
Epilobium glandulosum Lehm. [*E. ciliatum* Raf. ssp. *glandulosum* (Lehm.) Hoch & Raven] (Northern Willow Herb): R Scattered throughout. Often difficult to separate from the preceding taxa.
Epilobium leptophyllum Raf. (Fen Willow Herb): R Frequent throughout. (58 sites)
Epilobium strictum Muhl. ex Spreng. (Downy Willow Herb): NI, NS Rare in central. (5 sites)
Ludwigia palustris (L.) Ell. (Marsh Purslane): R Incidental. Rare on wet sand of discharge streams in east.
Oenothera biennis L. (Common Evening Primrose): Incidental. Rare on dry hummocks and margins.
Oenothera pilosella Raf. (Prairie Sundrops): Rare in extreme south.

Oxalidaceae

Oxalis violacea L. (Violet Wood Sorrel): Incidental. Rare on margins.

Polemoniaceae

Phlox maculata L. (Wild Sweet William): Common throughout.
Phlox pilosa L. (Prairie Phlox): Incidental. Occasional on dry hummocks and margins in west half.
Polemonium reptans L. (Jacob's Ladder): Frequent in east half.

Polygonaceae

Polygonum amphibium L. (Water Knotweed): R Scattered in east half.
Polygonum pensylvanicum L. (Pennsylvania Knotweed): Common throughout.
Polygonum sagittatum L. (Arrow-leaved Tear-thumb): Abundant throughout, becoming dominant with disturbance.
Rumex orbiculatus Gray (Great Water Dock): R, L Frequent throughout in very wet soils.

Primulaceae

Dodecatheon meadia L. (Shooting Star): Incidental. Rare in east central on dry margins.
Lysimachia ciliata L. (Fringed Loosestrife): Incidental. Scattered in central.
Lysimachia quadriflora Sims (Narrow-leaved Loosestrife): Abundant throughout, becoming most dominant in low vegetation mats.
Lysimachia terrestris (L.) BSP. (Swamp Candles): Incidental. Rare in margins.
Lysimachia thyrsiflora L. (Tufted Loosestrife): R Scattered throughout, often in very wet soil. (13 sites)

Ranunculaceae

Anemone canadensis L. (Canada Anemone): Incidental. Frequent on margins.
Anemone quinquefolia L. (Wood Anemone): Incidental. Rare on dry hummocks.
Caltha palustris L. (Marsh Marigold): Abundant throughout.
Ranunculus pensylvanicus L. f. (Bristly Buttercup): Frequent in east half.
Thalictrum dasycarpum Fisch. & Lall. (Common Meadow Rue): Common throughout.

Rosaceae

Agrimonia parviflora Ait. (Swamp Agrimony): R Frequent throughout.
Filipendula rubra (Hill) B. L. Robins. (Queen of the Prairie): R, L, E No extant populations seen on fen habitats although an old report exists from a Muscatine County site.
Fragaria virginica Duchesne (Wild Strawberry): Common throughout on dry hummocks and margins.
Geum aleppicum Jacq. (Yellow Avens): R Frequent throughout. More common than following species.
Geum laciniatum Murr. (Rough Avens): Occasional in dry margins.
Potentilla norvegica L. (Rough Cinquefoil): Frequent in disturbed sites.
Potentilla palustris (L.) Scop. [*Comarum palustre* L.] (Marsh Cinquefoil): R Rare throughout, absent from southeast. Prefers very wet soils. (7 sites)
Potentilla simplex Michx. (Common Cinquefoil): Incidental. Occasional on margins and dry hummocks.
Prunus virginica L. (Choke Cherry): Incidental. Rare in margins and thickets.
Rosa blanda Ait. (Early Wild Rose): Scattered throughout.
Rosa carolina L. (Pasture Rose): More common than preceding on dry hummocks and margins throughout.
Rubus occidentalis L. (Black Raspberry): Incidental. Rare in shrub thickets and margins.
Rubus pubescens Raf. (Dwarf Raspberry): NI, L Scattered and rare throughout. (8 sites)
Spiraea alba DuRoi (Meadowsweet): Common throughout.

Rubiaceae

Galium boreale L. (Northern Bedstraw): Frequent in east half on dry hummocks and margins.
Galium labradoricum (Wieg.) Wieg. (Bog Bedstraw): R, L, E Rare in north half. (4 sites)
Galium obtusum Bigelow (Wild Madder): Common throughout.
Galium tinctorium (L.) Scop. (Stiff Bedstraw): Occasional throughout.
Galium trifidum L. (Small Bedstraw): R, L Rare in north half in very wet soil. (2 sites)

Salicaceae

Populus tremuloides Michx. (Trembling Aspen): Occasional in northeast in thickets and margins.
Salix bebbiana Sarg. (Beaked Willow): Common in north half.
Salix candida Fluegge ex Willd. (Sage Willow): R, L, SC Locally frequent except in extreme east, where absent. (50 sites)
Salix discolor Muhl. (Pussy Willow): Common throughout.
Salix interior Rowlee. [*S. exigua* Nutt.] (Sandbar Willow): Incidental. Scattered on margins and discharge streams.
Salix lucida Muhl. (Shining Willow): R, L, E Rare in north half. No extant populations observed, but historical collections exist from at least three of the sites inventoried (Fitzpatrick, 1899; Tolstead, 1938; Hartley, 1966; Eilers, 1971).
Salix pedicellaris Pursh (Bog Willow): R, L, T Scattered and rare in north half. (11 sites)
Salix petiolaris Sm. (Petioled Willow): Common throughout.
Salix rigida Muhl. [*S. eriocephala* Michx.] (Heart-leaved Willow): Common throughout.
Salix sericea Marsh. (Silky Willow): NI, L Scattered in central. (5 sites)
Salix ×*clarkei* Bebb. (Clark's Willow): NI, NS Scattered over range of *S. candida.* (23 sites)
Salix ×*cryptodonta* Fern.: NI, NS Rare in west central. (2 sites)
Salix ×*rubella* Bebb. (Red Willow): NI, NS Scattered over range of *S. candida,* but less frequent than preceding. (13 sites)
Salix ×*subsericea* (Anders.) Schn. [*S. petiolaris* Sm.]: NI A few perplexing intermediates between *S. petiolaris* and *S. sericea* have been located in the north half, and may represent this taxon.
Salix candida Fluegge × *Salix pedicellaris* Pursh: NI, NS Very rare in sites of parental co-occurrence. (2 sites)

Santalaceae

Comandra richardsiana Fern. [*Comandra umbellata* Nutt. var. *umbellata*] (Bastard Toadflax): Incidental. On dry hummocks and margins.

Saxifragaceae
(including *Grossulariaceae*)

Heuchera richardsonii R. Br. (Prairie Alum Root): Incidental. Scattered throughout on dry hummocks and margins.
Parnassia glauca Raf. (Grass-of-Parnassis): R, L Frequently scattered throughout. (39 sites)
Penthorum sedoides L. (Ditch Stonecrop): Incidental. Occasional on muddy, disturbed margins.
Ribes americanum P. Mill. (Wild Black Currant): Scattered in north half in shrub thickets.
Saxifraga pensylvanica L. (Swamp Saxifrage): Common in all but northwest.

Scrophulariaceae

Chelone glabra L. (Turtlehead): R Common throughout. Six sites support populations of the fen restricted butterfly *Euphydryas phaeton phaeton,* which obligately feeds on this species.

Agalinis paupercula (Gray) Britt. (Fen False Foxglove): Scattered in central. Populations growing in very wet, cold soil approach var. *borealis* Pennell. (16 sites)

Agalinis purpurea (L.) Pennell (Purple False Foxglove): Scattered in southeast third. It is perhaps best to lump this and the preceding species, although *G. paupercula* var. *borealis* is quite distinct.

Agalinis tenuifolia (Vahl) Raf. (Slender False Foxglove): Incidental. Rare in extreme south.

Gratolia neglecta Torr. (Clammy Hedge Hyssop): Incidental. Rare in south third on muddy margins.

Mimulus glabratus HBK var. *fremontii* (Benth.) Grant. [*M. g.* var. *jamesii* (Torr. & Gray ex Benth.) Gray] (Yellow Monkeyflower): R, L, E Rare in discharge streams. (3 sites)

Mimulus ringens L. (Monkeyflower): Common throughout on margins.

Pedicularis lanceolata Michx. (Fen Betony): Common throughout.

Veronicastrum virginicum (L.) Farw. (Culver's Root): Frequent throughout.

Solanaceae

**Solanum dulcamara* L. (Bittersweet Nightshade): R Incidental. Rare on disturbed margins.

Ulmaceae

**Ulmus pumila* L. (Siberian Elm): R Scattered throughout on dry hummocks and shrub thickets.

Umbelliferae

Angelica atropurpurea L. (Giant Angelica): R, L, SC Frequent in northwest, very rare elsewhere. (8 sites)

Cicuta bulbifera L. (Bublet-bearing Water Hemlock): R Scattered throughout in wet soil.

Cicuta maculata L. (Water Hemlock): Frequent throughout.

Oxypolis rigidior (L.) Raf. (Cowbane): Common throughout. This is the most ubiquitous fen umbel.

Sium suave Walt. (Water Parsnip): R Uncommon throughout.

Zizia aurea (L.) W. P. J. Koch (Golden Alexanders): Scattered throughout on dry hummocks and margins.

Urticaceae

Boehmeria cylindrica (L.) Sw. (False Nettle): Most frequent in extreme east.

Parietaria pensylvanica Muhl. ex Willd. (Pellitory): Incidental. Rare on hummocks.
Pilea fontana (Lunnell) Rydb. (Spring Clearweed): R, L Frequent throughout. (63 sites)
Pilea pumila (L.) Gray (Clearweed): Incidental. Rare on disturbed, wooded margins.
Urtica dioica L. (Tall Nettle): Frequent in north half. Becomes dominant following disturbance.

Valerianaceae

Valeriana edulis Nutt. ex T. & G. (Common Valerian): R, L, SC Scattered in central. (17 sites)

Verbenaceae

Verbena hastata L. (Blue Vervain): Common throughout, particularly on disturbed margins.

Violaceae

Viola lanceolata L. (Lance-leaved Violet): R Rare in south third on wet, sandy margins. (4 sites)
Viola nephrophylla Greene (Northern Bog Violet): Abundant throughout. The most ubiquitous fen violet.
Viola pallens (Banks ex DC.) Brainerd [*V. macloskeyi* F. E. Lloyd ssp. *pallens* (Banks ex DC.) C. L. Hitchc.] (Smooth White Violet): R Scattered in central. (15 sites)
Viola primulifolia L. (Primrose Violet): R, L Rare in east. (1 site)
Viola sagittata Ait. (Arrow-leaved Violet): Incidental. Infrequent on dry margins.

Vitaceae

Parthenocissus vitacea (Knerr) A. S. Hitchc. (Thicket Creeper): Scattered throughout on dry hummocks and margins.
Vitis riparia Michx. (Wild Grape): Rare on shrub thickets.

MONOCOTYLEDONS

Alismataceae

Alisma subcordatum Raf. (Common Water Plantain): Occasional on muddy margins.
Sagittaria latifolia Willd. (Common Arrowhead): Frequent throughout in wet soil.

Araceae
(including *Acoriaceae*)

Acorus calamus L. (Sweet Calamus): Scattered throughout.

Symplocarpus foetidus (L.) Salisb. ex Nutt. (Skunk Cabbage): R Scattered in extreme east. (3 sites)

Cyperaceae

Carex annectens (Bickn.) Bickn. (Yellow-fruited Sedge): Scattered throughout.
Carex bebbii Olney ex Fern. (Bebb's Sedge): Scattered throughout.
Carex buxbaumii Wahlenb. (Buxbaum's Sedge): Frequent throughout.
Carex comosa Boott (Bristly Sedge): R Scattered throughout in very wet soil.
Carex cristatella Britt.: Uncommon on margins.
Carex diandra Schrank: R, L A single old collection only (Eilers, 1971), no extant populations observed.
Carex frankii Kunth (Frank's Sedge): R, L Rare in southeast on dry fen margins.
Carex granularis Muhl. ex Willd.: NI Scattered in north and northwest, preferring mineral rich soils. (9 sites)
Carex hystericina Muhl. ex Willd. (Bottlebrush Sedge): Common throughout.
Carex interior Bailey (Inland Sedge): Common throughout.
Carex lacustris Willd.: R Scattered in north half.
Carex laeviconica Dew.: R, L Rare in southeast. (1 site)
Carex lanuginosa Michx. (Woolly Sedge): Common throughout.
Carex lasiocarpa Ehrh. var. *americana* Fern.: NI Scattered in central on very wet soils. (6 sites)
Carex leptalea Wahl.: NI, L, E Rare in south third, typically associated with eolian sands. (5 sites)
Carex normalis Mackenz.: Scattered throughout on margins.
Carex prairea Dew. ex Wood. (Fen Sedge): R, L Common throughout. (92 sites)
Carex rostrata Stokes var. *utriculata* (Boott) Bailey [*C. utriculata* Boott]: R, L Scattered throughout. Prefers very wet soil conditions. (5 sites)
Carex sartwellii Dew.: R, L Absent in southeast, scattered elsewhere.
Carex scoparia Schkuhr ex Willd. (Pointed Broom Sedge) scattered throughout.
Carex sterilis Willd.: NI, NS Rare in central. (7 sites)
Carex stipata Muhl.: Uncommon in southeast on muddy margins.
Carex stricta Lam. (Tussock Sedge): Abundant throughout.
Carex suberecta (Olney) Britt.: R Absent from northwest (?), common elsewhere.
Carex tetanica Schkuhr: R,L Scattered in north half. (16 sites)
Carex tribuloides Wahl.: R Uncommon throughout.
Carex vulpinoidea Michx. (Fox Sedge): Common throughout on disturbed margins.
Cyperus rivularis Kunth. [*C. bipartatus* Torr.] (Brook Sedge): R Scattered and rare along discharge streams and in low vegetation mats.
Eleocharis acicularis (L.) R. & S. (Needle Spike Rush): R Incidental. Collected once (Eilers, 1971), but no extant populations observed.
Eleocharis elliptica Kunth. (Fen Spike Rush): NI Frequent throughout. This is our most ubiquitous fen *Eleocharis*. (51 sites)
Eleocharis palustris (L.) R. & S.: Scattered throughout.
Eleocharis smallii Britt. (Small's Spike Rush): NI Scattered and rare.
Eriophorum angustifolium Honckeny (Narrow-leaved Cotton Grass): R, SC Absent from extreme southeast, frequent elsewhere. (68 sites)

Eriophorum gracile W. D. J. Koch (Slender Cotton Grass): R, L, E No extant populations observed, however, old collections exist (Eilers, 1971).
Eriophorum virginicum L. (Tawny Cotton Grass): NI, NS Very rare in central in *Sphagnum* dominated fen on eolian sand ridge. (1 site)
Rhynchospora capillacea Torr. (Hairy Beak Rush): NI, L, T Rare and scattered in north half, preferring mats of very low vegetation. (8 sites)
Scirpus cyperinus (L.) Kunth. (Wool Grass): Frequent throughout.
Scirpus fluviatilis (Torr.) Gray (River Bulrush): R Incidental. Rare in extreme south.
Scirpus validus Vahl. [*S. tabernaemontani* K. C. Gmel.] (Great Bulrush): Frequent throughout. Often found in fens with mats of low vegetation.
Scleria verticillata Muhl. ex Willd. (Vanilla Nut Rush): NI, L, E Scattered and rare in central. Is restricted to mats of low vegetation. (6 sites)

Gramineae

**Agrostis alba* L. [*A. gigantea* Roth.] (Redtop): Frequent throughout.
Agrostis hyemalis (Walt.) BSP. (Tickle Grass): Occasional throughout.
Andropogon gerardii Vit. (Big Bluestem): Uncommon in west half on dry hummocks.
Bromus ciliatus L. (Fringed Brome): R Occasional in north half. (7 sites)
Calamagrostis canadensis (Michx.) Beauv. (Blue Joint Grass): Abundant throughout.
Calamagrostis inexpansa Gray [*C. stricta* (Timm) Koel. ssp. *inexpansa* (Gray) C. W. Greene] (Bog Reed Grass): NI Rare and scattered in extreme north.
**Digitaria sanguinalis* (L.) Scop. (Smooth Crabgrass): Incidental. Rare on disturbed margins.
Echinochloa crus-galli (L.) Beauv. (Barnyard Grass): R Incidental. Rare on disturbed margins.
Festuca paradoxa Desv. (Large Fescue): R Scattered throughout. (6 sites)
Glyceria grandis S. Wats. (Reed Manna Grass): R Occasional in very wet soil along discharge streams.
Glyceria striata (Lam.) A. S. Hitchc. (Fowl Manna Grass): Abundant throughout.
Hierochloe odorata (L.) Beauv. (Vanilla Grass): R Scattered in north half.
**Hordeum jubatum* L. (Squirrel-tail Grass): Incidental. Rare on dry hummocks.
Leerzia oryzoides (L.) Sw. (Rice Cut Grass): Frequent throughout, often in disturbed sites.
Muhlenbergia glomerata (Willd.) Trin. (Fen Wild Timothy): R, L Common throughout. (102 sites)
Muhlenbergia mexicana (L.) Trin. (Leafy Satin Grass): R Common throughout.
Panicum boreale Nash [*Dicanthelium boreale* (Nash) Frackmann] (Northern Panic Grass): NI, E Rare in south central, preferring dry hummocks and moist sand margins. (4 sites)
Panicum implicatum Scribn. [*Dicanthelium acuminatum* (Sw.) Gould & C. A. Clark var. *fasciculatum* (Torr.) Frackmann]: Common throughout on dry hummocks and low vegetation mats.
Phalaris arundinacea L. (Reed Canary Grass): Native species extensively planted for pasture 'improvement' on disturbed sites, where it becomes dominant.

Phragmites communis Trin. [*P. australis* (Cav.) Trin. ex Steud.] (Common Reed Grass): R Rare and scattered in north third.
**Poa compressa* L. (Canadian Bluegrass): Occasional throughout on margins.
Poa palustris L. (Marsh Bluegrass): Rare in wet soil.
**Poa pratensis* L. (Kentucky Bluegrass): Common throughout on margins.
Sorghastrum nutans (L.) Nash (Indian Grass): Incidental. Rare on dry hummocks and margins.
Spartina pectinata Link (Slough Grass): Scattered throughout on margins.
Sphenopholis intermedia (Rydb.) Rydb. (Slender Wedge Grass): R Common throughout.
Sphenopholis obtusata (Michx.) Scribn. (Prairie Wedge Grass): R Rare and scattered throughout.

Iridaceae

Iris virginica L. var. *shrevei* (Sm.) Anders. (Blue Flag): Common throughout.

Juncaceae

Juncus canadensis J. Gay ex Laharpe (Canadian Rush): R Incidental. Occasional on margins.
Juncus dudleyi Wieg. (Dudley's Rush): Common throughout.
Juncus nodosus L. (Joint Rush): R Absent from extreme southeast, scattered elsewhere where it is most typically found in mats of low vegetation.
Juncus tenuis Willd. (Path Rush): Incidental. Occasional on disturbed fen margins.
Juncus torreyi Coville (Torrey's Rush): R Incidental. Rare on fen margins.

Juncaginaceae

Triglochin maritimum L. (Common Bog Arrow Grass): NI, L, T Rare in northwest. (2 sites)
Triglochin palustre L. (Slender Bog Arrow Grass): NI, L, T Rare in central. (2 sites)

Lemnaceae

Lemna minor L. (Small Duckweed): Incidental. Uncommon in discharge streams.
Spirodela polyrrhiza (L.) Schleid. (Great Duckweed): Incidental. Uncommon in outlet streams.

Liliaceae

Hypoxis hirsuta (L.) Cov. (Yellow Star Grass): Incidental. Occasional on dry hummocks and margins.
Lilium michiganense Farw. (Michigan Lily): Incidental. Rare on dry hummocks and margins.
Melanthium virginicum L. (Bunchflower): R, L Incidental. Observed only once on badly degraded site in south central.

Smilacina stellata (L.) Desf. [*Maianthemum stellatum* (L.) Link] (Starry False Soloman's Seal): Incidental. Rare on dry hummocks and margins.
Zygadenus elegans Pursh (White Camass): R Scattered in north half on margins.

Orchidaceae

Cypripedium candidum Muhl. ex Willd. (White Lady's Slipper): R, L, T Rare in northwest half. (3 sites)
Cypripedium parviflorum Salisb. (Small Yellow Lady's Slipper): NI, NS Rare in central. (2 sites)
Cypripedium pubescens Willd. (Large Yellow Lady's Slipper): R, L Occasional in northeast.
Cypripedium reginae Walt. (Showy Lady's Slipper): R, L, E Rare in central. (1 site)
Cypripedium ×*andrewsii* A. M. Fuller (Andrew's Lady's Slipper): NI, L Rare in central. (1 site)
Cypripedium ×*favillianum* Curtis (Favill's Lady's Slipper): NI, NS Rare in central. (1 site)
Habenaria flava (L.) R. Br. var. *herbiola* (R. Br. ex Ait. f.) Ames & Correll [*Platanthera flava* (L.) Lindl. var. *herbiola* (R. Br. ex Ait. f.) Leur] (Green Orchid): R, L, E Rare in south third on wet, sandy margins. (2 sites)
Habenaria hyperborea (L.) R. Br. [*Platanthera hyperborea* (L.) Lindl.] (Northern Fringed Orchid): NI, L, T Very rare in north. (1 site)
Habenaria praeclara (Sheviak & Bowles) Cronq. [*Platanthera praeclara* Sheviak & Bowles] (Prairie Fringed Orchid): R, L, E Incidental. Rare in central. (1 site)
Habenaria psycodes (L.) Spreng. [*Platanthera psycodes* (L.) Lindl.] (Purple Fringed Orchid): R, L, T Scattered and rare throughout. (5 sites)
Liparis loeselii (L.) Rich. (Fen Twayblade): R, L Scattered throughout. (12 sites)
Spiranthes cernua (L.) Rich. (Nodding Lady's Tresses): Scattered throughout.
Spiranthes lucida (H. H. Eat.) Ames (Early Lady's Tresses): NI, NS, E Very rare in northeast. (1 site)

Typhaceae
(including *Sparganiaceae*)

Sparganium eurycarpum Engelm. ex Gray (Common Bur Reed): R Occasional throughout in very wet soil.
Typha angustifolia L. (Narrow-leaved Cattail): R Frequent thro ughout.
Typha latifolia L. (Common Cattail): Common throughout.